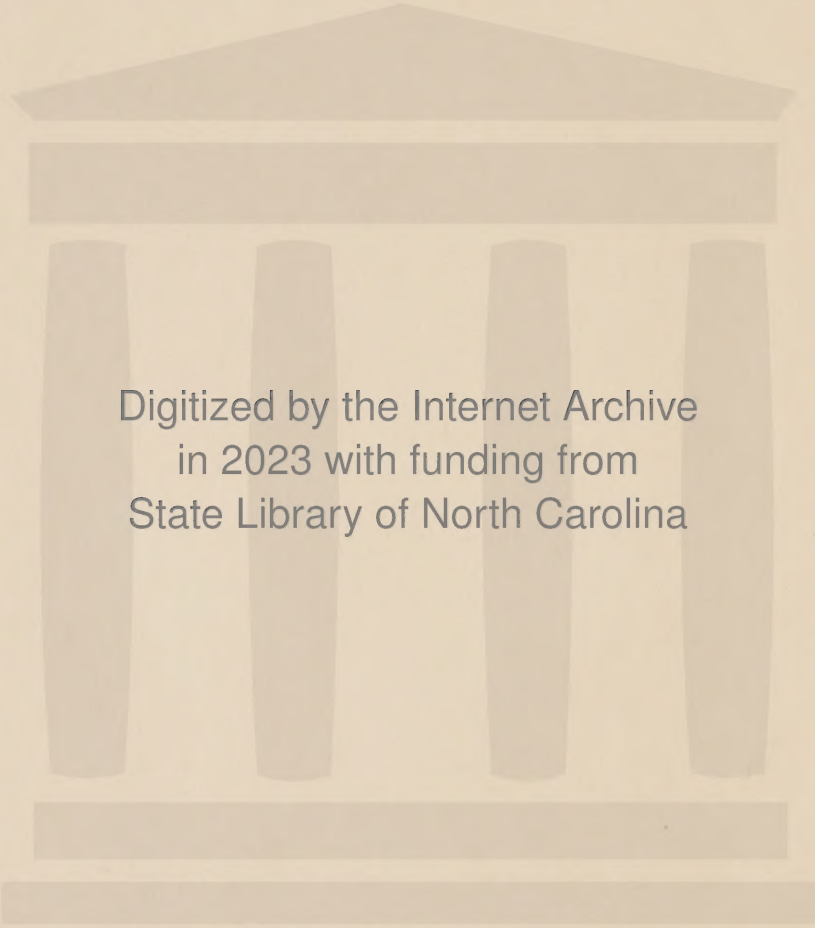


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Endangered and Threatened Plants and Animals of North Carolina

Editors:
John E. Cooper, Sarah S. Robinson, John B. Funderburg

ERRATA

<u>Page</u>	<u>Change (underlined)</u>
32	To list of federal endangered species in North Carolina, <i>add</i> : <u>Brown pelican, <i>Pelecanus occidentalis</i>.</u>
34	Line 20, change Authroity to <u>Authority</u> .
36	Line 2, change Cartaret to <u>Carteret</u> .
53	Line 5, change trou <u>p</u> to <u>trout</u> .
59	In line 3 of caption, close parentheses after (Wright's cliff-brake fern).
194	In line 5 of the footnote, change Lemat to <u>Lenat</u> .
200	In the "Species List," under Diplopoda, change Polydesmoidea to <u>Polydesmida</u> .
243	Add <u>A</u> to upper figure of the Atlantic Geoduck and <u>B</u> to lower figure.
304	In line 5 of "Habitat and Mode of Life," add <u><i>Platylepas hexastylus</i></u> after the word "barnacle."
336	In "Species List," change page numbers for the following as shown: <i>Laterallus jamaicensis</i> , Black Rail 379 to <u>378</u> <i>Coccyzus erythrophthalmus</i> , Black-billed Cuckoo 379 to <u>378</u> <i>Sphyrapicus varius</i> , Yellow-bellied Sapsucker 379 to <u>378</u> <i>Empidonax alnorum</i> , Alder Flycatcher 378 to <u>379</u> <i>Empidonax traillii</i> , Willow Flycatcher 378 to <u>379</u>
337	In "Species List," change page numbers for the following as shown: <i>Catharus (=Hylocichla) ustulatus</i> , Swainson's Thrush 378 to <u>379</u> <i>Helmitheros (=Limothlypis) vermivorus</i> , Worm-eating Warbler <u>378</u> to <u>379</u>
378	Change page number to <u>379</u> .
379	Change page number to <u>378</u> .

Note: The Editors apologize for allowing these errors to "creep in," and would be grateful to be informed of others.

Endangered and Threatened Plants and Animals of North Carolina

Proceedings of the Symposium on
Endangered and Threatened Biota
of North Carolina.

1. Biological Concerns

Meredith College, Raleigh
November 7-8, 1975

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Editor

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North Carolina State Library
Raleigh

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1. biological concerns. Held at Meredith College, Raleigh, NC,
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Endangered and Threatened Plants and Animals of North Carolina



Based on a Symposium
sponsored by the
North Carolina State Museum of Natural History

co-sponsored by the
North Carolina Department of Natural and Economic Resources
North Carolina Wildlife Resources Commission
North Carolina Academy of Science

Program of the Symposium

Friday, November 7. OPENING PLENARY SESSION AND GROUP WORKSHOPS
(Cate Auditorium)

- 1:00 PM -- Opening of Registration
- 1:55 PM -- Plenary Session
 - John E. Cooper, *North Carolina State Museum of Natural History*, Presiding
- 2:00 PM -- Opening Remarks
 - John B. Funderburg, Director, *North Carolina State Museum of Natural History*
- 2:10 PM -- Introduction of Steering Committee, and Group Committee Chairmen and Members
- 2:30 PM -- Beginning of Group Workshop Sessions (Hunter Hall);
Workshops open to observers
- 8:00 PM -- Social (Yates Pond Lodge)

Saturday, November 8. GENERAL ASSEMBLY (Jones Auditorium)

- 8:00 AM -- Registration continues
- 8:55 AM -- Opening of Assembly
 - Thomas L. Quay, *North Carolina State University*, Moderator
- 9:00 AM -- Welcome
 - John Hiott, *Meredith College*
- 9:10 AM -- KEYNOTE ADDRESS
 - James D. Williams, *Office of Endangered Species and International Activities, U. S. Fish and Wildlife Service, Department of the Interior*
- 10:00 AM -- Reports of Group Committee Chairmen and Discussions begin
(Plants; Birds)
- 11:00 AM -- Refreshment break
- 11:15 AM -- Reports and Discussions continue (Freshwater and Terrestrial Mollusks; Freshwater and Terrestrial Arthropods)
- 12:00 M -- Lunch break
- 1:30 PM -- Reports and Discussions continue (Marine Invertebrates; Marine Fishes; Freshwater Fishes; Amphibians and Reptiles)
- 2:50 PM -- Refreshment break
- 3:10 PM -- Reports and Discussions conclude (Mammals)
- 3:30 PM -- Comments and Discussion of Cluster Areas
- 4:00 PM -- Closing Remarks and Adjournment
 - John B. Funderburg

Symposium Coordinator: John E. Cooper

We are told that the trouble with Modern Man is that he has been trying to detach himself from nature. He sits in the topmost tiers of polymer, glass, and steel, dangling his pulsing legs, surveying at a distance the writhing life of the planet. In this scenario, Man comes on as a stupendous lethal force, and the earth is pictured as something delicate, like rising bubbles at the surface of a country pond, or flights of fragile birds.

But it is illusion to think that there is anything fragile about the life of the earth; surely this is the toughest membrane imaginable in the universe, opaque to probability, impermeable to death. We are the delicate part, transient and vulnerable as cilia. Nor is it a new thing for man to invent an existence that he imagines to be above the rest of life; this has been his most consistent intellectual exertion down the millennia. As illusion, it has never worked out to his satisfaction in the past, any more than it does today. Man is embedded in nature.

The biologic science of recent years has been making this a more urgent fact of life. The new, hard problem will be to cope with the dawning, intensifying realization of just how interlocked we are. The old, clung-to notions most of us have held about our special lordship are being deeply undermined.

- Lewis Thomas
from *The Lives of a Cell*

Preface

Little consideration has been given in past years to the effects of human activities on most wild flora and fauna. Although some species, notably those of direct economic value and a few of high aesthetic visibility, have received substantial attention, the welfare of the majority has been overlooked or ignored. This has been especially true of "insignificant" species of no obvious benefit or interest to mankind. As an inadvertent consequence, many forms have become extinct or locally extirpated, and many more now stand at the brink of a similar fate.

This phenomenon has been alarming to biologists, naturalists, and other knowledgeable citizens for quite a number of years. There were early warning voices -- those, for example, of Muir and Thoreau, of Marsh, Vogt, Leopold, Carson, and others -- decrying the destruction of natural environments and the attendant deletions of native flora and fauna. These went largely unheeded, however, and failed to precipitate the kinds of concerns needed for official or broad citizen action.

Fortunately, from the viewpoint of those who have identified good reasons to reverse the trend of impoverishment, the situation is now changing. Within the past decade a growing number of Americans, and governmental agencies at both state and federal levels, have also become cognizant that increasingly large segments of our natural wildlife heritage are in jeopardy. Some steps have been taken to investigate the problems and to implement programs to ameliorate or halt their effects. One such step, the federal Endangered Species Act of 1973 (Public Law 93-205), has made it incumbent upon all states to assess the current condition of their native animals and plants, identify those of concern, and formulate plans for their protection and recovery. The Act addresses the general question by pointing out that "these species of fish, wildlife, and plants are of esthetic, ecological, historical, recreational, and scientific value to the Nation and its people."

North Carolina, with its great physiographic and habitat diversity, is rich in plant and animal species. It has been known for a number of years, however, that many of these are to one degree or another in difficulty, and some have apparently disappeared. In 1973 a group of area biologists formed an Endangered Species Committee, under the aegis of the North Carolina Department of Natural and Economic Resources, and in June of that year produced the "Preliminary List of Endangered Plant and Animal Species in North Carolina." In September, 1974, the State Museum of Natural History, long involved with studying our total biota, was informally requested to assume responsibility for further defining and periodically reviewing the status of all species of concern. The first step in meeting this responsibility was the Symposium on Endangered and Threatened Biota of North Carolina, organized by the Museum and held at Meredith College, Raleigh, November 7-8, 1975.

The idea of convening a state-wide symposium, bringing together the best available biological expertise on North Carolina's fauna, originated in a motel room in Tuscaloosa, Alabama, on the eve of a March, 1975, meeting on the condition of certain biota of that state in which I participated. A quick organizational sketch was drawn up at that time, and modified as the stronger and weaker points of that meeting became apparent. Thus, we are indebted to Herb Boschung, Director of the Alabama Museum of

Natural History, for helping focus original vague ideas. I subsequently learned, through Dan Pittillo, that the Conservation Committee of the North Carolina Academy of Science had tentative plans for taking action on endangered species. After we had had an opportunity to discuss our mutual interests, the Academy agreed to act as a co-sponsor for the projected symposium. Because of their pioneer work on rare and endangered biota, the North Carolina Department of Natural and Economic Resources was also invited to participate in a similar capacity and generously agreed. A third state agency, the North Carolina Wildlife Resources Commission, was additionally asked to co-sponsor the event because of their developing programs on non-game species and their management and enforcement functions.

Consideration of plants was not included in the initial planning, since area botanists were already well ahead of zoologists in organizing to express their concerns. Following a meeting that involved botanists from throughout the state, however, Jim Hardin suggested that our efforts be combined into a single symposium. For thus adding immeasurably to our burden, he was asked to chair the Group Committee on Plants.

A Steering Committee was selected, consisting of those persons indicated on the inside front cover. This group discharged its responsibilities with immediacy, and nothing would have been possible without the great interest of every member. The objectives of the Symposium, as drawn by the Steering Committee, are found in the "Charge to Group Committees" which follows this Preface. Specialists in various taxa responded generously and enthusiastically to our call for expertise. This was all the more remarkable since we were unable to provide them any form of financial assistance, a commodity which is itself an endangered, if not extinct, species for state-level meetings of this nature.

Over 200 people attended the Symposium, 170 of them registered participants, representing a host of state and federal agencies, institutions of higher learning, companies in the private sector, citizens groups, and naturalists organizations. They came from all over North Carolina, and from the District of Columbia, Florida, Georgia, Louisiana, Maryland, Pennsylvania, South Carolina, Tennessee, and Virginia. Their names and addresses are provided as Appendix B.

The success of this Symposium was the direct result of a great deal of planning, homework, and legwork on the part of many people other than the Steering Committee. The members and Chairmen of each Group Committee put a multitude of long, thoughtful hours into both pre-Workshop organization and Workshop discussions, as reflected in the excellent summary presentations at Saturday's General Assembly. Some committee members were unable to attend the meetings, but made invaluable contributions from as far away as Illinois, Mississippi, and Ontario, Canada. The names and addresses of all these workers are provided in Appendix A.

We were privileged to meet on the fine campus of Meredith College, and are grateful to John E. Weems, President, for this opportunity and for providing us with amenities well above the usual. We are indebted to Clara Bunn and Marie Mason for making all arrangements for meeting areas and apparatus, and enabling us to use the college dining facilities. John Hiott welcomed the General Assembly to the campus and stressed Meredith's continuing, and demonstrated, interest in public service. Don Ellington aided us with public address and recording equipment.

Many participants were quite vocal in their praise of the fluidity with which all aspects of the Symposium proceeded. This would have been virtually impossible without the selfless efforts of many Museum personnel and friends who donated their time, energies, equipment, and private transportation in attending to the multitudes of details inherent in such an undertaking. We commend and thank Alvin Braswell, Mike and Susanne Browne, Eve Cleaver, Martha Cooper, Donna Ennis, Dorothy Gard, Dave and Barbara Lee, Brenda Merritt, Bonnie Woodall, Dawn Newkirk, Bill Palmer, Fred Scott, Susan Smith, Will Thomson, and Ed Van Riper for their contributions. The Raleigh Chamber of Commerce, through Maryruth Reiss and Paul DelaCourt, assisted us with information, name tags, and certain equipment.

We thank Jim Williams for a fine keynote address, which provided definite perspective on the problem and values of endangered species. We are also grateful to Tom Quay, who performed a yeomans service as Moderator of the General Assembly on very short notice.

After the Symposium the Steering Committee agreed to sit as a Proceedings Committee to plan and expedite this publication, and Sarah Robinson, to whom would fall much of the production task, was added. Production of this volume was the work of the Editors, aided in some areas by Kathryn Poston and Donna Maynard of the Museum's Education Division. The cover design and layout are the work of Peter Dornville, Sarah Robinson, and Susan Templeton, all of the Museum. The stylized drawing of Venus' Fly-trap which appears on the half title page is the work of the Museum's scientific illustrator, Renaldo Kuhler.

Finally, neither the Symposium nor its Proceedings would have materialized without the enthusiastic support and participation of John B. Funderburg, Director of the North Carolina State Museum of Natural History. As can be seen throughout the pages of this volume, he wore many hats during the course of the meetings and production of the book. As a measure of the man, it might be noted that one of these hats was the weary cap of a broom-pusher in the aftermath of Friday night's social at Yates Pond Lodge.

John E. Cooper

North Carolina State Museum of Natural History
Raleigh
October 1976

Charge to Group Committees

Each Group Committee Chairman was charged with selecting a committee to, among other things:

I. Consider taxa (species and subspecies) of its assigned group with respect to determining and reporting their *status* as:

A. *Endangered*

1. within the confines of the state; this includes peripheral forms which may be quite common elsewhere but whose continued existence as part of the North Carolina biota is clearly and imminently at hazard; in danger of extirpation;

2. nationwide, i.e. included in or being considered for the U. S. List of Endangered Fauna and Endangered and Threatened Plant Species of the United States, under the Endangered Species Act of 1973 (Public Law 93-205); in danger of extinction (perhaps on a worldwide basis).

B. *Threatened*

1. within North Carolina; forms which are likely to become *Endangered* within the foreseeable future if certain conditions are not met; forms which exhibit a considerable decrease in numbers deemed beyond the limits of normal fluctuation, or documented range contraction, but not yet considered *Endangered*.

2. nationwide, under the provisions of Public Law 93-205.

C. *Special Concern*

1. because they exist in small populations (are rare) over a relatively broad range;

2. because they are targeted for exploitation which could become extensive enough to pose a threat;

3. because certain characteristics or requirements make them especially vulnerable to specific pressures; or

4. for other reasons identifiable by experienced researchers.

D. *Undetermined*

1. because of insufficient data for precise assessment (suggestions for research aimed at generating these data are pertinent); and

E. *Recently Extinct or Extirpated*

1. as indicated by historical documents and/or knowledge of committee members (each committee shall establish its definition of "recently").

II. Additionally, consider demes of taxa within its assigned group with respect to determining their significance and status within a physiographic or other unit, or other importance. According to Public Law 93-205, "The term 'species' can include any species, any subspecies, and any smaller taxonomic unit of plant or animal, and also any viable population-segment thereof."

III. Prepare a preliminary "in-committee" report of its findings on each species, etc., which will be brought to the first day Group Committee Workshop for finalization.

IV. Identify important sites of concentration (cluster areas) for *Endangered* and *Threatened* forms in a variety of taxa.

V. Prepare a 15 or 20 minute presentation indicating its findings, to be delivered by the Chairman or his representative at the General Assembly. Since this Assembly will be open to the public, various agency representatives, and other interested parties, the presentation should largely be geared for a non-technical audience.

VI. Address only biological concerns, documenting all claims as fully as possible and identifying those areas where data are unavailable and research is imperative. Other concerns (legal, legislative, management) will be considered in planned future symposia.

Five factors used by the federal Office of Endangered Species and International Activities to determine *Endangered* or *Threatened* status:

1. The present or threatened destruction, modification, or curtailment of its habitat or range;
2. Overutilization for commercial, sporting, scientific, or educational purposes;
3. Disease or predation;
4. The inadequacy of existing regulatory mechanisms; and
5. Other natural or manmade factors affecting its continued existence.

Table of Contents

<i>Program of the Symposium</i>	v
<i>Preface</i>	viii
<i>Charge to Group Committees</i>	x
General Introduction <i>John E. Cooper</i>	1
The Setting	13
Species in Jeopardy	16
Some of the General Problems	26
The Values Involved	31
What is Being Done?	37
Ultimate Questions and Answers	38
About This Volume	
Symposium Keynote Address	
Endangered Species: Yesterday, Today, and Tomorrow? <i>James D. Williams</i>	49
Vascular Plants <i>James W. Hardin and Committee</i>	
Introduction <i>James W. Hardin</i>	56
County Distributions of Plants of Primary Concern	64
List of Species of Primary Concern	65
Accounts of Species of Primary Concern	68
List of Peripheral Species	132
Discussion	139
Freshwater and Terrestrial Mollusks <i>Samuel L. H. Fuller</i>	
Introduction	143
Species List	154
Accounts of <i>Endangered</i> Species and Those Presumed <i>Extinct</i>	155
Accounts of <i>Threatened</i> Species	171
Accounts of Species of <i>Special Concern</i>	179
Accounts of Species of <i>Undetermined Status</i>	185
Discussion	192
Freshwater and Terrestrial Arthropods	
Introduction <i>Tom Daggy</i>	195
A Comment on Coleoptera <i>James F. Cornell, Jr.</i>	197
A Comment on Crayfishes <i>Martha R. Cooper and John E. Cooper</i>	198
Species List	200
Species Accounts and Annotated Lists <i>Authors Indicated</i>	
<i>Threatened Species</i>	203
Species of <i>Special Concern</i>	209
Species of <i>Undetermined Status</i>	226
Discussion	229
Other Invertebrates <i>John E. Cooper and Rowland M. Shelley</i>	231
Marine Invertebrates	
Introduction <i>Hugh W. Porter, Charles Johnson, and</i> <i>Anne B. McCrary</i>	233
Species List	237
Accounts of Species of <i>Special Concern</i> <i>Authors Indicated</i>	237
Discussion	249
Marine Fishes <i>Frank J. Schwartz, William W. Hassler, John W.</i> <i>Reintjes, and Michael W. Street</i>	
Introduction	250

Species List	252
Account of Possibly <i>Extirpated</i> Species	252
Accounts of <i>Depleted</i> Species	254
Accounts of Species of <i>Special Concern</i>	258
Freshwater Fishes <i>Joseph R. Bailey and Committee</i>	
Introduction <i>Joseph R. Bailey</i>	265
Watersheds and Critical Areas <i>Joseph R. Bailey</i>	268
Species List	278
Accounts of Possibly <i>Extirpated</i> Species	282
Accounts of <i>Endangered</i> Species	287
Accounts of <i>Threatened</i> Species	294
Discussion	297
Amphibians and Reptiles	
Introduction <i>Richard C. Bruce</i>	299
Species List	302
Species Accounts <i>Authors Indicated</i>	
<i>Endangered</i> Species	303
<i>Threatened</i> Species	312
Species of <i>Special Concern</i>	316
Comment on Species of <i>Undetermined Status</i>	329
Birds <i>James F. Parnell and Committee</i>	
Introduction <i>James F. Parnell</i>	330
Species List	335
Accounts of <i>Endangered</i> Species	338
Accounts of <i>Threatened</i> Species	347
Annotated List of Species of <i>Special Concern</i>	369
Annotated List of Species of <i>Undetermined Status</i>	377
Discussion	382
Mammals	
Introduction <i>David S. Lee and John B. Funderburg</i>	385
Species List	390
Species Accounts <i>Authors Indicated</i>	
<i>Endangered</i> Species	392
<i>Threatened</i> Species	398
Species of <i>Special Concern</i>	400
Annotated List of Species of <i>Undetermined Status</i>	402
Marine Mammals	407
Cluster Areas <i>Robert P. Teulings and John E. Cooper</i>	
Introduction	409
Coastal Plain	410
Piedmont Plateau	419
Blue Ridge	421
Discussion	431
Epilogue <i>The Editors</i>	
How to Cite This Volume and its Sections	434
Appendix A <i>Group Committees</i>	436
Appendix B <i>Conferees</i>	439

FIGURES

General Introduction

- Fig. 1. Map of North Carolina showing counties and physiographic provinces. 3

Vascular Plants

- Fig. 1. Relative rareness of plants as a function of distribution and density. 58
- Fig. 2. Types of distributions of North Carolina rare plants. 59
- Fig. 3. Distributions of the 91 extinct, endangered, and threatened plant species, as indicated by the number of species in each county. 61
- Fig. 4. *Pellaea X wrightiana*, Wright's cliff-brake fern. 69
- Fig. 5. *Cystopteris X tennesseensis*, Tennessee bladder fern. 70
- Fig. 6. *Sagittaria fasciculata*, Bunched arrowhead. 72
- Fig. 7. *Calamagrostis porteri*, Porter's reedgrass. 73
- Fig. 8. *Calamovilfa brevipilis*, Riverbank sandreed. 74
- Fig. 9. *Poa languida*, Torrey bluegrass. 75
- Fig. 10. *Sporobolus heterolepis*, Prairie dropseed. 76
- Fig. 11. *Sporobolus teretifolius*, Wireleaf dropseed. 77
- Fig. 12. *Trisetum spicatum* var. *molle*, Soft trisetum. 77
- Fig. 13. *Carex aenea*, Fernald's hay sedge. 78
- Fig. 14. *Carex biltmoreana*, Biltmore sedge. 79
- Fig. 15. *Carex chapmanii*, Chapman's sedge. 79
- Fig. 16. *Carex misera*, Wretched sedge. 80
- Fig. 17. *Carex purpurifera*, Purple sedge. 81
- Fig. 18. *Cymophyllus fraseri*, Fraser's sedge. 81
- Fig. 19. *Helonias bullata*, Swamp-pink. 84
- Fig. 20. *Narthecium americanum*, Bog asphodel. 85
- Fig. 21. *Trillium pusillum* var. *pusillum*, Carolina trillium. 86
- Fig. 22. *Habenaria flava*, Southern rein-orchid. 86
- Fig. 23. *Habenaria integra*, Yellow fringeless-orchid. 87
- Fig. 24. *Habenaria peramoena*, Purple fringeless-orchid. 88
- Fig. 25. *Isotria medeoloides*, Small whorled pogonia. 89
- Fig. 26. *Listera cordata*, Heart-leaved twayblade. 90
- Fig. 27. *Gale palustris*, Sweet gale. 91
- Fig. 28. *Betula papyrifera* var. *cordifolia*, Mountain paper birch 92
- Fig. 29. *Buckleya distichophylla*, Piratebush. 93
- Fig. 30. *Nestronia umbellula*, Nestronia. 93
- Fig. 31. *Hexastylis lewisii*, Lewis' heart leaf. 95
- Fig. 32. *Portulaca smallii*, Small's portulaca. 96
- Fig. 33. *Arenaria uniflora*, Single-flowered sandwort. 97
- Fig. 34. *Hydrastis canadensis*, Goldenseal. 98
- Fig. 35. *Ranunculus subcordatus*, Bladen buttercup. 99
- Fig. 36. *Schisandra glabra*, Magnoliavine. 100
- Fig. 37. *Sarracenia rubra*, Sweet pitcher-plant. 102
- Fig. 38. *Sedum rosea*, Roseroot. 103
- Fig. 39. *Dionaea muscipula*, Venus' fly-trap. 104
- Fig. 40. *Saxifraga careyana*, Carey saxifrage. 105
- Fig. 41. *Dalibarda repens*, Robin-run-away. 107
- Fig. 42. *Geum geniculatum*, Bent avens. 108
- Fig. 43. *Geum radiatum*, Spreading avens. 108
- Fig. 44. *Cladrastis lutea*, Yellowwood. 109
- Fig. 45. *Ilex amelanclhier*, Sarvis holly. 111
- Fig. 46. *Hudsonia montana*, Mountain golden heather. 112
- Fig. 47. *Panax quinquefolium*, Ginseng. 113
- Fig. 48. *Lilaeopsis carolinensis*, Carolina lilaeopsis. 114

Fig. 49. <i>Ptilimnium fluviatile</i> , Stream mockbishopweed.	115
Fig. 50. <i>Rhododendron bakeri</i> , Cumberland azalea.	116
Fig. 51. <i>Rhododendron vaseyi</i> , Pink-shell azalea.	117
Fig. 52. <i>Pyxidanthra barbulata</i> var. <i>brevifolia</i> , Wells' pyxie moss.	118
Fig. 53. <i>Shortia galacifolia</i> , Shortia or Oconee bells.	119
Fig. 54. <i>Synandra hispidula</i> , Synandra.	121
Fig. 55. <i>Utricularia olivacea</i> , Dwarf bladderwort.	122
Fig. 56. <i>Eupatorium resinsum</i> , Resinous joe-pye-weed.	126
Fig. 57. <i>Helianthus schweinitzii</i> , Schweinitz' sunflower.	127
Fig. 58. <i>Rudbeckia heliopsidis</i> , Sun-facing coneflower.	128
Freshwater and Terrestrial Mollusks	
Fig. 1. <i>Elliptio waccamawensis</i> , Waccamaw Spike.	163
Fig. 2. <i>Elliptio waccamawensis</i> , Waccamaw Spike.	163
Fig. 3. " <i>Lampsilis</i> " <i>radiata</i> complex, Waccamaw Mucket.	165
Fig. 4. " <i>Lampsilis</i> " <i>radiata</i> complex. Orton Pond.	166
Fig. 5. " <i>Lampsilis</i> " <i>radiata</i> complex. Internal morphology.	167
Fig. 6. " <i>Lampsilis</i> " <i>radiata</i> complex. Kennebec River, Maine.	167
Fig. 7. <i>Elliptio lanceolata</i> complex, Waccamaw Lance.	175
Fig. 8. <i>Elliptio lanceolata</i> complex. Chowan River.	176
Fig. 9. <i>Elliptio lanceolata</i> complex. Chowan River.	176
Fig. 10. " <i>Lampsilis</i> " <i>ochracea</i> , Waccamaw Mucket.	183
Fig. 11. " <i>Lampsilis</i> " <i>ochracea</i> . Chowan River.	183
Fig. 12. " <i>Lampsilis</i> " <i>ochracea</i> , gravid female. Chowan River.	189
Fig. 13. <i>Elliptio</i> sp., File Spike.	189
Fig. 14. <i>Ligumia nasuta</i> , Eastern Pondmussel.	191
Freshwater and Terrestrial Arthropods	
Fig. 1. Dorsal view of anterior of a crayfish, showing rostrum, areola, and carapace length.	199
Marine Invertebrates	
Fig. 1. <i>Argopecten gibbus</i> , Calico Scallop.	243
Fig. 2. <i>Panopea bitruncata</i> , Atlantic Geoduck.	243
Fig. 3. Distribution of <i>Argopecten gibbus</i> beds, and <i>Neritina usnea</i> locality.	244
Fig. 4. Distribution of <i>Panopea bitruncata</i> .	244
Fig. 5. <i>Neritina usnea</i> , Olive Nerite.	245
Freshwater Fishes	
Fig. 1. Watersheds of North Carolina.	269

TABLES

General Introduction

Table 1. Numbers of jeopardized vertebrates in North Carolina and the United States.	13
--	----

Vascular Plants

Table 1. County distributions, plants of primary concern	64
Table 2. Vascular plants of primary concern.	65
Table 3. Peripheral, native and rare species.	132

Birds

Table 1. History of the Brown pelican nesting colony at Ocracoke Inlet.	339
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General Introduction

by
John E. Cooper

This general introduction is intended to serve as an overview of some of the biotic attributes and other characteristics of North Carolina's physiographic regions, certain aspects of the forces which have placed many of our plants and animals in jeopardy, the reasons for our concerns (the values involved), and some of the efforts being made to solve these problems at federal and state levels. No such lengthy introduction was presented at the Symposium on Endangered and Threatened Biota of North Carolina. It was written to facilitate the use of this book as a more complete educational tool. Although the topics are too briefly discussed to make this part of the book more than a primer, sufficient references are provided to enable the interested reader to pursue these subjects further. The introduction closes with comments on the objectives and composition of this volume.

The Setting

A hike across North Carolina, transecting the state from the deep shadows of a spruce-fir forest high along the Tennessee border to the edge of a bright beach on the Outer Banks, would cover more than 800 kilometers (500 miles) and cross three major physiographic provinces. If the route included Mount Mitchell in the Black Mountains, the highest peak in eastern North America, it would labor through a range of elevations totalling nearly 2,100 meters (7,000 feet), revealing that the land, climate, flora, and fauna of the Tarheel State are perhaps the most varied in the eastern United States.

North Carolina's 56,712 square miles includes large segments of the Atlantic Coastal Plain, the Piedmont Plateau, and the Blue Ridge (part of the Appalachian Highlands)(Figure 1). The state's climate is generally that of a "humid subtropical region" (Kopec and Clay 1975), but there is considerable variation in temperature, precipitation, and length of growing season. Many major rivers and their tributary streams flow through North Carolina, and most of them originate within the borders of the state. The Coastal Plain, Piedmont, and eastern slopes of the Blue Ridge are drained by a dozen major river basins emptying eventually into the Atlantic Ocean. Three of these — the Cape Fear, Neuse, and Tar systems -- are endemic to the state, rising and ending within its confines and harboring some species not found elsewhere. Other Atlantic drainage rivers are shared with neighboring states. Some originate here and pass through Georgia and South Carolina before reaching the ocean, while others head in Virginia and terminate on our coast. By contrast, the western slopes of the mountains are drained by four major river systems that flow to the Mississippi River and thence to the Gulf of Mexico. Three of these flow west to traverse the tortuous course of the Tennessee River. The fourth, bearing the incongruous name New River, is recognized as the most ancient river in North America and one of the most interesting. This unique river begins in the northeastern mountains of North Carolina, and its waters flow north and west into the Kanawha,

General Introduction -- Coastal Plain

reaching the Gulf of Mexico by way of the Ohio and Mississippi rivers. All of the watersheds of the state, as well as some major freshwater lakes, are illustrated and discussed in the chapter on *Freshwater Fishes*.

Three distinct water masses interface in the Atlantic Ocean off North Carolina's coast. One of them, the north flowing Gulf Stream, brings waters from the Caribbean and parallels the coast, sometimes over 48 kilometers (30 miles) at sea. It takes an abrupt eastward swing as it meets the south flowing Labrador Current off Cape Hatteras. The area of contact is the infamous Diamond Shoals, a place of mixing and turmoil. These currents meet with the masses of Virginia and North Carolina coastal waters to produce different marine faunal zones, which are briefly considered in the introduction to the chapter on *Marine Fishes*. The effect of this zonation on the composition of some segments of the North Carolina marine invertebrate fauna is discussed in the introduction to the chapter on these animals.

The flora of the state consists of approximately 3,400 taxa of vascular plants (Hardin, this volume) and an unknown number of lower plants. Its vertebrate fauna of over 865 species and subspecies includes some 200 freshwater fishes, 78 amphibians, 79 reptiles, 225 breeding and 175 winter and transient birds, 80 non-marine mammals, and 28 pelagic or offshore mammals (NCSM 1977). The known invertebrate species number in the tens of thousands, quite a few undescribed and many yet to be recorded or even discovered.

Coastal Plain

The *Coastal Plain* in North Carolina extends from the Atlantic as a broad flatland, stretching from Virginia to the South Carolina border and inland as far as Northampton County in the north, Harnett County centrally, and Richmond County in the south. It covers approximately 45% of North Carolina's area, and about 30% of the state's population resides in its 41 counties. This is probably the youngest physiographic province in the United States, with a surface consisting almost exclusively of Cenozoic sediments, loosely joined or unconsolidated as limestones, marls, sands, gravels, and clays, varying in age from Cretaceous to Recent (Stuckey 1965). The coastal climate is quite mild, resulting in about 300 freeze-free days per year in the easternmost areas. Average annual rainfall is variable throughout the province, but generally ranges from 107 to 120 centimeters (42 to 47 inches) and is greatest in the extreme east. The Coastal Plain is traversed by a number of rivers which head within its confines, including the Chowan, Lumber, New, Pamlico, Pasquotank, Trent, Waccamaw, and White Oak, and by the Cape Fear, Neuse, Roanoke, and Tar, which originate farther west.

Several distinctive if not precisely delimited sections of the Coastal Plain can be recognized. The offshore barrier islands, known in North Carolina as the *Outer Banks*, are sand reefs which fringe the Atlantic coast from Bogue Inlet east to Cape Lookout and north to the Virginia line, jutting far out into the ocean at Cape Hatteras. They are separated from the mainland by broad sounds or shallow bays of varying dimension, the widest being Pamlico Sound, containing extensive marshes and open lagoons. From Bogue Inlet west and south to Cape Fear and on to the South Carolina line, the islands continue as a string of elongate barrier beaches paralleling the coast. The immediate mainland area inland from the sounds and barrier strands is a low region, known as the

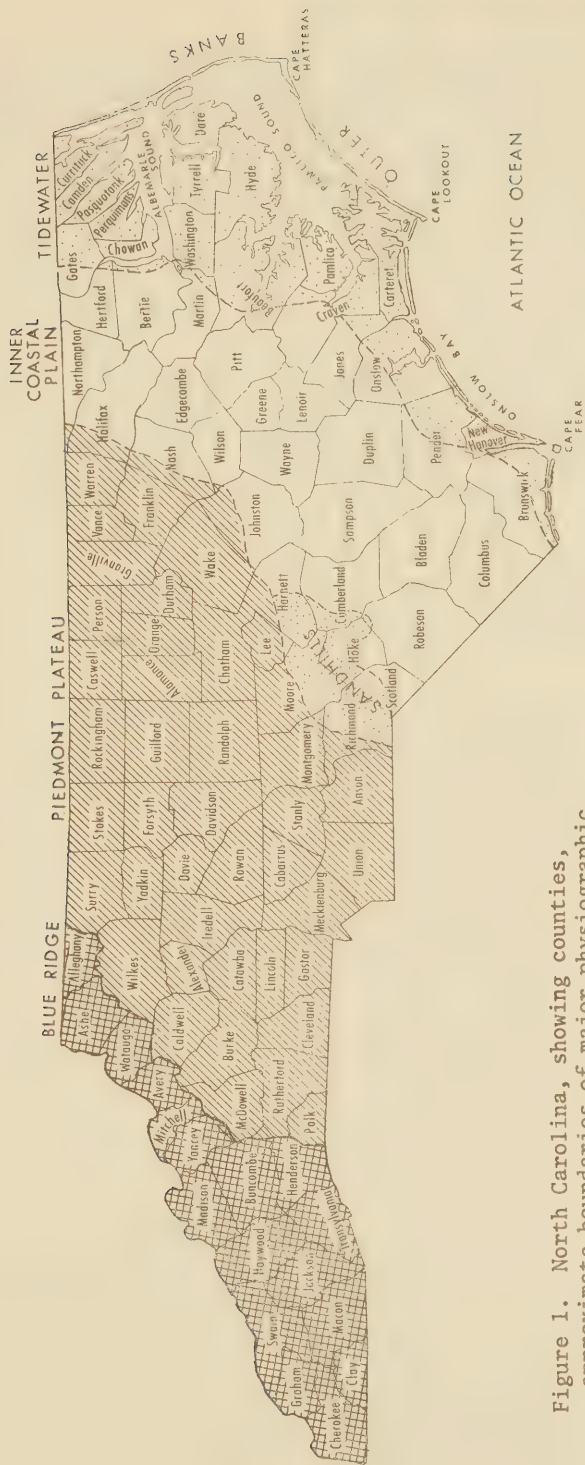


Figure 1. North Carolina, showing counties, approximate boundaries of major physiographic provinces, and local subdivisions of the Atlantic Coastal Plain.

General Introduction -- Outer Banks

Tidewater, where elevations seldom reach three meters (less than ten feet) and the rivers are strongly affected by Atlantic tides. To the west of the Tidewater is an extensive *Inner Coastal Plain* which is quite varied, assuming progressively higher profile and better drainage, and dissected by many of the major rivers previously mentioned. The southwestern part of this region, covering parts of Harnett, Moore, Hoke, Richmond, and adjacent counties, is a unique dry area known as the *Sandhills*. Elevations here may reach 150 to 220 meters (about 500 to 740 feet), and deep sand ridges are characteristic of, but not limited to, this area.

Although these coastal subdivisions are alike in many respects, each has certain characteristic biotic, physical, and other features, some of which are discussed below. Throughout most of the Coastal Plain the dominant forests are pine, especially in sandier soils which drain quickly. These forests have historically maintained their competitive advantage over encroaching hardwoods through natural fire maintenance (Gleason and Cronquist 1964). In areas with richer soils, however, especially where fire has been eliminated or controlled, pines only persist at the more inhospitable sites. Only remnants of former large, primary stands of oak-hickory forest occur in this province. Their major trees include White, Southern red, Water, Willow, Post, and Swamp chestnut oaks, several kinds of hickories, Sweet and Black gums, Tulip poplar, Beech, and Red maple.

Outer Banks

Like the adjacent mainland coast, these islands are sea-level terrain whose surface consists of Quaternary sands and clays. Jockey's Ridge, a gigantic dune nearly 42 meters (138 feet) high located at Nags Head, is the tallest pile of sand on the Atlantic coast. Much of it is now contained in a state park. Other public lands on the barrier islands include Cape Hatteras National Seashore, which occupies some 28,000 acres of Bodie, Hatteras, and Ocracoke islands; Pea Island National Wildlife Refuge on Hatteras Island; and the recently established Cape Lookout National Seashore, encompassing Core and Shackleford banks and Portsmouth Island. The most popular of our state parks, Fort Macon, is located at the eastern end of Bogue Banks.

The plant and animal communities of these unstable barrier islands, while depauperate when compared with the rich communities of the other coastal areas, are unusual in some respects. This is especially true of the zone between Capes Hatteras and Lookout where Dwarf palmetto reaches its northernmost limit in the hammocks of Buxton Woods. The rare kingsnake which occurs in this intra-Capes zone is considered by some herpetologists to be an endemic subspecies known as the Outer Banks Kingsnake (Lazell and Musick 1973). North and southwest of this zone the flora is very similar to that of the adjacent mainland, although Cabbage palmetto edges into the islands of Brunswick County. With a few exceptions, the fauna of the Banks consists mostly of ecologically tolerant forms that are rather widespread in the Coastal Plain and some that are essentially statewide in distribution.

Relatively few plants occur on the outer beaches of the islands, where tides, strong winds, and salt spray create very restrictive conditions. Stands of Seaside spurge, Sea rocket, and Seabeach amaranth, however, are found there. Characteristic animals of the open beach and surf include several kinds of crustaceans, like Ghost and Mole crabs. Porpoises can often be seen plying the coast, and a number of species of

whales, listed in the chapter on *Mammals*, have been stranded on these beaches. As indicated in the same chapter, the Florida manatee apparently moves into the adjacent coastal waters in summer, at least as far north as Cape Lookout. The giant Atlantic Leatherback, largest living turtle, is known to have nested on one occasion at Cape Lookout, and other species of sea turtles, discussed in the chapter on *Amphibians and Reptiles*, periodically occur in the Atlantic off the Outer Banks and in the sounds behind them. One of these, the Atlantic Loggerhead, nests on our beaches. Many kinds of coastal birds fly the beaches and surf, and in autumn large numbers of hawks migrate south over the islands, as discussed in the chapter on *Birds*.

Perennial grasses like Sea oats and Beach grass grace the beaches and dunes back from the ocean strand, while certain herbs help stabilize the slopes and crests. Wandering over the sands may be found an occasional Eastern Hognose Snake, and the Eastern Glass Lizard, a legless species, is often found in the lee of the dunes. A surprising number of invertebrates inhabits these open areas.

In the depressions and wet, marshy "blow outs" beyond the dunes the groundcover increases, and prevalent species are Broomsedge, Spurge, and Seaside pennywort. Freshwater ponds are occasional in open areas. An example is Mullet Pond on Shackleford Banks, choked with Cattails, where the Marsh killifish occurs. Inland, somewhat removed from the surf but still affected by blowing sand and salt spray, grow maritime shrub thickets. Here windward growth is stunted, and the plants, mostly Wax myrtle, Red cedar, and Yaupon, are flag form and biased to the lee. Still farther inland, away from the worst of the saline conditions, are true maritime forests. Southwest from Cape Lookout their dominant species is the evergreen Live oak, with Juniper, Red bay, and American holly, while on the islands more to the north the forests are mostly of pine, beech, hickory, and Hop hornbeam. Here may be found the Pinewoods Snake, known from Roanoke Island and Shackleford and Bogue banks, with its type locality a few miles west of Fort Macon. As in all of the Coastal Plain, many of the major island trees are draped with that epiphytic herald of the south, Spanish moss. The lower vegetation of some of the islands is subject to considerable damage from the grazing of introduced goats, sheep, and horses.

The marshes of the sounds and shallow bays west and south of Beaufort Inlet are marked, in the saline or brackish tidal zone, by dense growths of Smooth cordgrass, while above high tide this vegetation changes to Saltmeadow cordgrass and Saltgrass. These marshes teem with life, including myriad crustaceans, other invertebrates, and a variety of estuarine fishes. Many coastal birds nest and winter in this area. Along the coast and islands above Beaufort Inlet the prominent outer marsh vegetation consists of Black needlerush, with Saltmeadow cordgrass and Saltgrass behind. The Carolina Salt Marsh Snake is found in these habitats, along the islands and mainlands of Core and Pamlico sounds, and the Carolina Diamondback Terrapin inhabits the marsh areas, laying its eggs in the sandy shores. Cooper et al. (1975) indicate that at one time there was a total of 900,600 acres of estuarine marsh in the state, the greatest on the Atlantic coast. Dredge and fill operations have altered or destroyed thousands of acres, despite the fact that some 95% of the commercial fish and shellfish of the area depend on these marshes for

General Introduction -- Tidewater

their survival (Cooper et al. 1975). It is interesting to note that, based on its energy flow, Gosselink et al. (1974) placed a value of \$82,940 per acre on unmodified salt marsh. And, as pointed out by Ehrenfeld (1976), this appraisal did not even include those qualities that cannot yet be assigned a conventional value. A number of publications have discussed the biological, legal, and other aspects of North Carolina's coastal zone. References can be found in Bode and Farthing (1974).

Tidewater

The *Tidewater* is essentially a series of peninsulas, with an outer periphery of broad estuaries and tidal regions. According to Heath et al. (1975), North Carolina's tidal shoreline is the sixth longest in the nation, measuring some 5,600 kilometers (3,500 miles). There are a number of freshwater marshes in this part of the Coastal Plain, notably along the fringes of the lower Cape Fear River, and Albemarle and upper Currituck sounds. These marshes, dominated by Cattail, Bulrush, Sawgrass, and Big cordgrass, are the home of many amphibians, turtles, small and medium-sized mammals, and a host of waterfowl. In early summer they ring with the honking calls of the Green Treefrog. The American Alligator roams their edges and open waters, as well as coastal estuaries and lakes, from the Pamlico River south.

Part of the Great Dismal Swamp enters the state in northeastern Tidewater. Here are found a number of unique mammals, including local races of the Short-tailed shrew, Southeastern shrew, and Meadow vole, and an isolated population of the Southern bog lemming. The Black bear persists in the depths of this swamp, the beautiful Prothonotary warbler flits through its trees and shrubs, and a disjunct population of the Black-throated green warbler occurs there.

The peninsula between Albemarle Sound and the Pamlico River, often called the East Dismal Swamp, is an area of some faunal discontinuity. Species like the Northern Water Snake, and Eastern Painted and Red-bellied turtles, occur north of the Pamlico River, and the Southern Chorus Frog, Southern Hognose Snake, Eastern Diamondback Rattlesnake, Chicken Turtle, and other species occur to the south. Several coastal reptiles, like the Carolina Black Swamp Snake and Carolina Pygmy Rattlesnake, seem to reach their northern range limits near Albemarle Sound.

Although much of the Tidewater is changing due to extensive draining of swamps and marshes, one relatively intact tract of public land in the region is Croatan National Forest, covering parts of Carteret, Craven, and Jones counties. There are also approximately 15,000 acres of the Great Dismal Swamp National Wildlife Refuge in North Carolina, and the state has recently received large tracts of the swamp from corporate donors. A number of big lakes, the only natural lakes in the state, occur in the Coastal Plain. In Tidewater they include Lake Mattamuskeet, which covers 67 square miles in Hyde County and is part of a wildlife refuge, and Phelps Lake, 25 square miles of water in Washington County, edged by Pettigrew State Park. Degradation of the latter lake is discussed in the chapter on *Freshwater Fishes*. Lake Ellis, one of the five "Great Lakes" of the Croatan, supports a population of alligators, and Anhingas and Double-crested cormorants are known to nest at this site.

Inner Coastal Plain

West of Tidewater the southeastern Coastal Plain is marked by thousands of "Carolina Bays," which are shallow peat-fills characterized by Bay and Cypress trees. In this region, also, are extensive swamps, like the Green Swamp of Columbus and Brunswick counties, Angola Swamp in Pender and southern Duplin counties, and Wolf Swamp in Onslow and Jones counties. Along the blackwater rivers that almost imperceptibly drain the area are swamp forests of Bald cypress, and Tupelo and Swamp gums, which predominate in areas where water characteristically stands for considerable periods of time. White cedar may persist where water does not accumulate to significant depths, but it is no longer abundant (Wells 1967). A common vine of these forests is Cross-vine. Because of the heavy canopy, herbaceous plants are few. In the floodplains and swamps along the rivers occur the Star-nosed mole, Marsh rabbit, and Rice rat. Amphibians and reptiles of these habitats and area ponds include the Greater Siren, Two-toed Amphiuma, and other salamanders, and a wide variety of frogs, toads, turtles, and snakes. Many bird species nest here, or migrate through. The freshwater aquatic vegetation is rich, and includes Tape grass, Bladderwort, Pondweed, Arrow-leaved spatterdock, Duckweed, and other species.

The faster moving rivers support adjacent floodplain forests of Willow, Water, and Cherrybark oaks, Sweet gum, Ash, River birch, and other major trees. Almost all of the forests are barbed with dense growths of Greenbrier, and thickened with Poison ivy and Virginia creeper. Some of the rivers and their tributaries contain unique fishes and aquatic invertebrates. Their associated herpetofauna includes some of the species mentioned above, plus River and Florida Cooters, the Dwarf Waterdog, and, to the northeast, the endemic Neuse River Waterdog of the Neuse and Tar rivers, which also occurs in the Piedmont sections of these rivers.

Probably the best known of the natural lakes of the Inner Coastal Plain is Lake Waccamaw, home of three species of unusual fishes. Two of these are apparently endemics, but the other is shared with Phelps Lake. Waccamaw is also the site of occurrence of more unique non-marine mollusks, especially mussels, than anywhere else in the state, and the Waccamaw Helix, a terrestrial snail, occurs in the area. These are discussed in detail in the chapter on *Freshwater and Terrestrial Mollusks*.

Biologists working in the Coastal Plain will encounter dense thickets of evergreen shrubs known as *pocosins*, an Indian term for "swamp on a hill." In their truest form these slow-draining bogs of fluctuating water table occur on the peaty soils of extensive flats, as in the Green Swamp, but also develop in Carolina Bays and as the "Bay-heads" between ridges of sand. One particularly impressive pocosin area is Holly Shelter in southern Pender County. The major shrubs of pocosins are Titi or Leatherwood, Gallberry, Fetter bush, Honey cup, Cane, and Sweet pepperbush. Sweet and Red bays and Pond pine are scattered throughout, and the floor is usually covered with Sphagnum, other mosses, and organic debris, giving it a spongy quality. These are the haunts of the Black bear and Eastern Diamondback Rattlesnake, the latter preferring the drier pocosins. Persistent rumors of Panthers come from coastal areas containing dense stands of these thickets. The Pine Barrens Treefrog occurs in ponds, streams, and ditches in and around these habitats. Also around pocosins and on flat semi-bogs, especially in burned areas, Venus' fly-trap usually occurs in abundance.

General Introduction -- Sandhills and Piedmont Plateau

Higher land supports the open savanna habitats, characterized floristically by Longleaf and Pond pines, Wire grass, and such shrubs as Gallberry, Sweet bay, and Wax myrtle. Other plants make up the lower story and ground cover, and these areas are famous for their seasonal wildflower displays, diversity of carnivorous plants, and terrestrial orchids. They are also famous amongst zoologists as a primary habitat of certain reptiles, including the Canebrake Rattlesnake, until recently considered a subspecies of the Timber Rattlesnake but now afforded no separate status.

Sandhills

Still farther west, in the region known as the *Sandhills*, the Coastal Plain becomes quite xeric, and the characteristic vegetational community of this deep sand area consists of Longleaf pine, Turkey oak, and Wire grass. Humus here is virtually non-existent, and the white sands are often coated with broad but thin patches of lichens. Huge forests of Longleaf pine once prevailed, but are now gone. The rare Wells' or Sandhill pyxie moss is known from this habitat in Harnett and Moore counties. Characteristic herbs of the Sandhills are discussed by Wells (1967). The major strongholds of the Red-cockaded woodpecker, Eastern Coachwhip, Northern Pine Snake, Tiger Salamander, and Carolina Gopher Frog occur in the pinewoods of this interesting section of the Coastal Plain. The rare Coral Snake is also found here. Stretches of this habitat occupy other parts of the coastal province.

Piedmont Plateau

The Coastal Plain essentially ends, and the Piedmont Plateau begins, at a broad, meandering zone some 45 to 65 kilometers (30 to 40 miles) wide known as the Fall Line. This name derives from the fact that streams from the northwest experience an increase in gradient here, and numerous waterfalls, like Falls of the Neuse, are present. The Piedmont, which covers some 26,000 square miles or about 40% of the state's area, is a region of rolling topography and red, rocky soils, rising gradually from 90 to 180 meters (300 to 600 feet) elevation along the Fall Line, to around 450 to 600 meters (1,470 to 1,970 feet) at the eastern escarpment of the Blue Ridge. Monadnocks, isolated groups of mountains, and long ridges, are abundant in this province, including Pilot Mountain and the Uwharrie, Sauratown, Kings, Brushy, and South mountains. Outlying spurs of the Blue Ridge, like the Saluda, Linville, Tryon, and White Oak mountains, penetrate the western Piedmont.

Unlike the Coastal Plain, the Piedmont Plateau is underlain with older igneous and metamorphic rocks. Average rainfall here ranges from 105 to 120 centimeters (41 to 47 inches) per year. The climate is somewhat harsher than that of the coastal areas, and there are 200 or fewer frost-free days annually. The province is drained by swift rivers, notably the Broad, Cape Fear, Catawba, Dan, Neuse, Tar and Yadkin, and their tributaries. This is the most extensively developed physiographic region of North Carolina, and timbering, grazing, farming, and especially urbanization (about 53% of the state's population resides in the 34 Piedmont counties), have changed the formerly wooded landscape into a patchwork of urbanized areas, roads, fields, forests, and major municipalities.

Several hundred years ago the uplands were covered with oak-hickory forests, but now there are only remnants. These are characterized by White, Red, Scarlet, Southern red, Black, Chestnut, and Post oaks, and Mockernut and Pignut hickories. Other common species are Tulip poplar, Black gum, Loblolly pine, Sourwood, and Dogwood. The fauna of these woodlands and surrounding areas throughout the province, while not as rich as that of the Coastal Plain, is still quite varied. Most of it consists of species that are statewide in distribution. Interestingly, some parts of the Piedmont are not very well known as far as the specific composition and distribution of certain faunal groups are concerned. This is illustrated by the fact that an undescribed species of crayfish was recently discovered in a tributary of the Neuse River near Raleigh, and nearly every collecting trip by State Museum biologists yields new information on arthropods, amphibians, reptiles, and small mammals. Field efforts have apparently been somewhat more intensive in the mountain and coastal areas of the state, although some aspects of their fauna are also not particularly well known. As might be expected, a few primarily coastal species, like the Marsh rice rat, Eastern harvest mouse, Rough Earth Snake, and Squirrel and Pine Woods Treefrogs, encroach on the lower Piedmont. Similarly, some species which are primarily mountain in distribution, like the Bog Turtle and Timber Rattlesnake, occur in parts of the Piedmont. Wehrle's Salamander is found in the extreme northwestern part of this province, the only known site for this animal in the state.

The major river floodplains support limited hardwood swamp forests containing Sycamore, River birch, Elm, Ash, Tulip poplar, and Swamp chestnut and Willow oaks. Through the Slate Belt of the central Piedmont are still some stands of Carolina shagbark hickory. A disjunct stand of Hemlock persists at Hemlock Bluffs, Wake County, and an isolated area of White pine occurs in the vicinity of the confluence of the Rocky and Deep rivers, Chatham and Lee counties. Hemlock and White pine are species characteristic of the mountains.

The Piedmont is a good study in community succession. Some of the first investigations of this process in the United States took place here. Many formerly cultivated fields have been abandoned, and show the progressive stages of recovery, from Crabgrass, through Horseweed and Broom-sedge, to early trees like Loblolly, Shortleaf, and Virginia pines. Early and old fields support large populations of small mammals like the Eastern harvest mouse, Cotton rat, Meadow and Pine voles, and Eastern cottontail. Around their edges are White-footed and Golden mice, and the Meadow jumping mouse, Striped skunk, and Red fox are occasionally seen. Some fields have been lying fallow long enough to revert to oak-hickory climax.

Many of the state's 48,000 ponds, lakes, and reservoirs are found in this province. These include Lake Norman on the Catawba River, the largest man-made lake in the state, with a surface area of over 32,000 acres; Hyco Reservoir on the Hyco River; and the High Rock, Baden, and Tillery lakes string on the Yadkin. Some of our most popular state parks are in the Piedmont, including Morrow Mountain, Umstead, Hanging Rock, and Pilot Mountain. Uwharrie National Forest covers much of Montgomery County and part of Randolph County. A large number of recent Panther sightings have been reported from this region, and at least one of the several Piedmont sites of the Red-cockaded woodpecker occurs here.

Blue Ridge

The Piedmont Plateau ends fairly abruptly in the west at a ragged escarpment, where elevations soaring 450 to 750 meters (1,480 to 2,460 feet) mark the beginning of the *Blue Ridge* province. This is a land of majestic mountains and deep intermont valleys, the Land of the Sky, part of the long Appalachian chain which rises in southeastern Canada and fades in northeastern Alabama. These mountains attain their grandest spectacle in western North Carolina, where there are more than 80 with peaks at 1,500 to 1,800 meters (4,900 to 5,900 feet), and some even higher. The province encompasses about 6,000 square miles, or 12% of North Carolina's area, and only about 15% of the state's population resides in its 25 counties. Here is found the most rigorous climate in North Carolina, with lower mean temperatures and fewer freeze-free days (150) than anywhere else in the state. Heavy snowfalls mark the winter season, and the annual precipitation may be from 112 to 145 centimeters (44 to 57 inches) per year. This is variable within the Blue Ridge, however, and slopes of southern exposure along the South Carolina line may get as much as 150 to 250 centimeters (54 to 98 inches), while annual precipitation in the sheltered rain shadow of the French Broad Valley around Asheville is the state low of about 92 centimeters (36 inches) (Stuckey and Steel 1953).

The Blue Ridge is a heavily dissected, high elevation plateau bordered on the east by the Blue Ridge Mountains. These attain usual heights of 900 to 1,200 meters (2,950 to 3,940 feet), although some, like Grandfather Mountain, are higher. The western border is bounded by greater mountains reaching heights of 900 to 1,800 meters (2,950 to 5,900 feet), including the Bald, Great Smoky, Stone, Unaka, and Unicoi ranges. Connecting these bounding chains southwest of Grandfather Mountain are the cross ridges and broad river valleys of the Black Mountains, which include 2,005 meter (6,684 feet) high Mount Mitchell, the Balsam, Nantahala, New Found, and Pisgah mountains, and others.

Most of the rivers of the Blue Ridge flow over an even gradient at these high elevations, but some exit the plateau and plunge to lower elevations in crashing waterfalls and cascades, like Toxaway and Whitewater falls. Because the crest of the Appalachians marks the Eastern Continental Divide, Blue Ridge rivers like the Elk, French Broad, Hiwassee, Little Tennessee, New, Nolichucky-Toe, Pigeon, and Watauga flow to the west and become part of the drainages of the Kanawha and Tennessee rivers moving to the Gulf of Mexico. Some 6,340 square miles drain in this direction. The fish and benthic invertebrate faunas of these rivers are rich and include a number of rare and endemic species. The French Broad is, or perhaps was, the home of a number of fishes recorded from no other system in the state, including the Paddlefish and Mooneye. The giant salamander known as the Hellbender occurs in the drainages of several of these rivers. East of the divide Savannah headwaters like the Chatooga, Horsepasture, Thompson, Toxaway, and Whitewater rivers, and others like the Broad, Catawba, Green, and Yadkin, flow inexorably to the Atlantic, draining over 46,000 square miles and slowed only temporarily by their journey across the broad Coastal Plain.

Like the Piedmont Plateau, the Blue Ridge is based on older rocks, mostly pre-Cambrian crystalline gneisses and schists, with inclusions of normal igneous rocks like granite. Areas of Cambrian sedimentary rocks are also present. Growing in the acid soils are two major vegetational

types, each composed of several recognizable subtypes. At lower elevations, in the valleys and on the mountain slopes to about 1,650 meters (5,400 feet), are deciduous forests, while the highest elevations support relict stands of boreal or northern conifer forests and related forms. The southern Appalachian flora is very rich, and one reason is that "this area has been continuously available for habitation by land plants since late Paleozoic times, probably longer than the angiosperms themselves have existed." (Gleason and Cronquist 1964). The fauna is also rich, especially in certain groups like the salamanders and wood warblers, and endemic species are abundant, notably in certain arthropod groups.

In protected valleys and on lower slopes the floral assemblages are mixed mesophytic and extremely varied. The best concentrations of these famous "cove hardwoods" are found in the Great Smoky Mountains National Park and other public lands, where there may be 25 to 30 species of trees in a single stand. Such assemblages are characterized by Silverbell, White basswood, Yellow birch, Yellow buckeye, Sugar maple, Tulip poplar, Beech, and Hemlock. Low elevation ravines and bottoms are dominated by Hemlock, and these forests also persist in mesic areas at higher elevations. The understory is a thick confusion of Rosebay rhododendron and Doghobble, with an abundance of pteridophytes and montane herbs. Oaks, not sharply delimited from the communities of the Piedmont, grow on the open slopes up to about 1,500 meters (4,900 feet). On outer slopes of southern and eastern exposure below 900 meters (2,950 feet), and in the interior montane basins, the oak-hickory phytotype is predominant. The major species here are White and Chestnut oaks, with Black, Red, and Scarlet oak also prevalent. Red maple, Dogwood, Black gum, Black locust, and Sourwood are common, and Mountain laurel and Blueberry dominate the shrubs. At higher elevations the Northern red oak becomes important, and is congregated with Scarlet oak, Sourwood, and Red maple. The remains of American chestnut, brought low by the blight which had effectively killed all mature trees by the late 1930's, are here in abundance. The understory is primarily Rosebay rhododendron, Mountain laurel, and Flame azalea.

Pine or pine-oak forests occupy the more xeric ridges and precipitous slopes of southern to southwestern exposure at lower elevations. Open stands of Pitch and Virginia pines are the most common evergreens up to around 750 meters (2,450 feet), and also at the lower elevations here are Shortleaf pine, Scarlet and Chestnut oaks, Red maple, Black gum, and Sourwood, and a shrub layer similar to that of the oak-hickory association. The fauna of the low and intermediate elevation forests includes several species of rare shrews, Golden, Red-backed, and Deer mice, the Least weasel, the Black bear, amphibians like the Mountain dusky, Blue Ridge Two-lined, Zigzag, Valley and Ridge, Yonahlossee, and Appalachian Woodland salamanders, and the Wood Frog. Very convincing Panther sightings are frequently reported from remote woodlands in these areas. The rare Green Salamander frequents rock outcrops and cliffs in the southwest, and a number of populations of the Bog turtle and Bog lemming are also known here, in open bogs and sedge meadows.

The extreme of plant communities in the Blue Ridge is the boreal conifer forest of Red spruce and Fraser fir, which occurs at elevations above 1,350 to 1,500 meters (4,430 to 4,920 feet). A great deal of logging, fire, and at least one major pest have reduced the extent of these forests greatly in recent years, as discussed in the Saw-whet owl account

in the chapter on *Birds*, and in the Northern flying squirrel account in the *Mammals* chapter. The most complete stands are now in the Great Smoky, Black, Balsam, and Plott Balsam mountains, where Red spruce and Fraser fir make up some 95% of the forests at elevations over 1,800 meters (5,900 feet). The only other major trees occurring in these forests in any abundance are Yellow birch, Mountain ash, and Fire cherry. A ground cover of ferns and herbs is well developed, and liverworts and mosses are rampant. The Saw-whet owl, Olive-sided flycatcher, Black-capped chickadee, and several other birds are essentially limited to these forests as breeding species. This is the habitat of Weller's Salamander in North Carolina, and of the Red squirrel or "boomer." The arthropod fauna contains many unique species, as can be seen in the chapter on *Freshwater and Terrestrial Arthropods*.

Another prominent feature of the high elevations between 1,200 and 1,800 meters (3,940 and 5,900 feet) are the open, treeless areas known as *balds*. Dense heath balds or "laurel slicks," consisting of tangles of Rhododendron and Mountain laurel, are as difficult to penetrate as the coastal pocosins. Added to the difficulties imposed by their density, however, is the fact that they exist in precipitous and rugged terrain. They reach the zenith of development in the Smokies, but Roan Mountain and the Craggies also have their rhododendron balds or "pink beds." High grass balds, at 1,560 to 1,740 meters (5,100 to 5,700 feet) elevation, are thick mats usually consisting of Mountain oat grass with such shrubs as Flame azalea, Blackberry, and Blueberry, and small Shadblow, Hawthorn, and other trees rising out of them. These balds, where Golden eagles probably nested and may still be seen from time to time, are apparently diminishing through successional encroachment, and must be managed if they are to persist. The general fauna of the mountain balds is poorly known.

Undoubtedly the least known habitats in the mountains are the caves which occur there. Systematic faunal explorations have only recently begun, as a cooperative effort between the State Museum of Natural History and a chapter of the National Speleological Society based in Old Fort, McDowell County. Preliminary sampling has resulted in the discovery of new invertebrate species, and new records for the state of species previously described. Some of these caves have fairly large winter bat populations, but their specific identity is currently unknown.

There is a great deal of public land in the mountains of North Carolina. Most of the 1.5 million acres of national forests and parks in the state occur there, as do several major state forests and parks. These include Great Smoky Mountains National Park, shared with neighboring Tennessee; Nantahala and Pisgah National forests; Joyce Kilmer Memorial Forest; and Mount Mitchell and Mount Jefferson State parks. A number of large impoundments, like Fontana Lake on the Little Tennessee River, and Lake Hiwassee on the river of the same name, are in this province.

Species in Jeopardy

North Carolina, then, has a diverse and abundant biota, containing many species found nowhere else in the world, and occupying varied habitats in three major physiographic provinces. As the accounts in this book make quite clear, however, many of the species making up this outstanding natural heritage are to one degree or another in jeopardy, and some have already been exterminated.

The Committee on Vascular Plants identified 91 species of primary concern to knowledgeable botanists and another 319 of additional concern, which is approximately 12% of the state's total of some 3,400 taxa. By comparison, the Smithsonian Institution (1974) list of jeopardized plants contains 2,099 taxa in the continental United States, 100 of which are recently or possibly extinct, 761 endangered, and 1,238 threatened, which is about 10% of the flora of the 49 states. For Hawaii the number in all categories of jeopardy is naturally smaller, 1,088, but this is nearly 49% of the known flora of the islands. On a worldwide basis the same report says, "It has been estimated that, of the approximately 300,000 species of plants of the world, over 20,000 [15%] are endangered or vulnerable and threatened with extinction by the year 2000."

The committees charged with determining the status of North Carolina's vertebrates (excluding all but seven marine forms) considered 25 taxa (or populations in the case of some freshwater fishes) *Endangered*, 28 *Threatened*, 84 of *Special Concern*, and 51 of additional concern but so little known that they must be categorized as status *Undetermined*. Omitting the *Undetermined* group, 137 are of major concern, roughly 21% of the state's vertebrate fauna of around 663 species and subspecies (excluding 175 non-breeding birds). Table 1 provides a breakdown of North Carolina vertebrates of concern, and a comparison with numbers of native United States vertebrate species in the federal lists (*Endangered Species Technical Bulletin* 1(4):3).

Table 1. Numbers of jeopardized vertebrates in North Carolina and the United States (federal lists). E = Endangered, T = Threatened, SC = Special Concern, U = Undetermined.

	North Carolina				United States	
	E	T	SC	U	E	T
Mammals	3 ¹	1	1	24	35	1
Birds	4	19	39	18	65	1
Reptiles	7	1	3	3	8	0
Amphibians	0	2	7	6	4	0
Freshwater Fishes ²	11	5	34	—	30	4

¹Excludes six species of whales and the Gray myotis, *Myotis grisescens*.

²Includes certain populations of some species (see species list in chapter on *Freshwater Fishes*). Excludes four species possibly extirpated, and also excludes the questionable Lake sturgeon, *Acipenser fulvescens*, and the Shortnose sturgeon, *A. brevirostrum*.

General Introduction -- Natural versus Man-induced Extinctions

Except for a few species, it is difficult to accurately assess the status of our marine and estuarine fauna, particularly the vertebrates. This is due to "jurisdictional" problems, since the marine system is not conveniently discontinuous, and insufficient knowledge of many of the forms. Of the 26 marine mammals other than the Manatee recorded in North Carolina waters in the *Mammals* chapter, 6 kinds of whales are on the federal list as *Endangered* throughout their ranges. Nine of our marine fishes are considered to be of primary concern, one of them *Endangered* and possibly *Extirpated* (the Shortnose sturgeon) and eight of *Special Concern*. Another four are considered seriously *Depleted* by commercial take. Eleven marine invertebrates are of *Special Concern*.

Similarly, a paucity of information makes it nearly impossible at this time to determine the status or even the numbers of North Carolina's non-marine invertebrate species. The Committee on Freshwater and Terrestrial Mollusks reported 28 mussels and snails of major concern, and, although the molluscan fauna is incompletely known in North Carolina, Fuller estimated this to be about 10% of our non-marine species. The only other group for which any serious effort was made was the largest animal phylum, the Arthropoda, and the committee considering this fauna could not identify any taxa as *Endangered*. Because of the insufficiency of data, however, this does not mean that there are no such arthropods in North Carolina. They did recognize 5 as *Threatened*, 56 of *Special Concern*, and another 20 of sufficient concern to be listed as *Undetermined*. This is a very small percentage of the approximately 16,000 arthropod species known to occur in North Carolina, but, as indicated in the chapter on these animals, our extremely limited knowledge of them precludes assessment of all but a few of the better known groups.

At any rate, it is quite obvious that biologists are very much concerned about the status of a large segment of our biota, and the time is long past for asking, "What kinds of forces are at work that can place so many of our native plants and animals in jeopardy of extinction or serious depletion?" The following section will attempt to provide general answers to this question. Before considering these problems, however, comment will be made on an argument often proposed against our concerns for species in danger of extinction, and an important caveat will be inserted.

Natural versus man-induced extinctions

A number of people advance the notion that concerns like those expressed in this book are not very valid because extinction, after all, is a natural process. They are right, in a sense, since extinction is indeed the eventual fate of most species. The number of different kinds of plants and animals in existence today is but a fraction of those that have come and gone, as evidenced by the fossil record. But, as Jim Williams pointed out in his Keynote Address, the big flaw in this argument lies in comparing the time scale for natural extinctions with the rapidly accelerating rate of those which are man-induced. This increasing rate is illustrated by the fact that over half of the 47 major wildlife species that became extinct in the United States since 1700 disappeared within the last 50 years. Myers (1976) indicates that the current worldwide extinction rate is one species or subspecies of animal per year, as compared with an approximate rate of one every ten years from 1600 to 1950. Ziswiler (1967) postulates a natural extinction rate of perhaps one species every

thousand years during the demise of the dinosaurs. Fisher et al. (1969) provide specific figures for extinctions of higher vertebrates which further document this acceleration.

Thus, extinction as a natural process occurs on a vast geological time scale, through mechanisms like the evolution of more successful forms adapting to environmental change. In the "grand scheme" there appears to be a tendency towards a dynamic equilibrium of diversity, with species loss not outpacing species gain. Today, however, the extinction process is acting on a very small time scale, and there is no counterbalance in species gain on the same scale. This causes serious dislocations, and we can currently only guess at the repercussions of most of them.

An important caveat

While crisis response is a necessary and unfortunate legacy of our uninformed actions of the past, and we must make every emergency attempt to assure that our biological diversity suffers no further unnecessary erosion through loss of these "basket cases," emphasis on specific endangered and threatened species must not detract from efforts to *preserve natural ecosystems* in their totality. First of all, endangered and threatened species cannot realistically be separated from the rest of the biotic world, and the only relatively sure way they can be saved is by the intact preservation of varied and complex areas. Secondly, the list of species in jeopardy can only grow longer if ecosystem integrity is ignored in our planning, since the numbers of forms which are not now endangered will eventually become depleted to the point of concern. We must therefore plan for the retention of natural ecosystems wherever they might occur, and assure that maximum diversity is maintained. The cost-effectiveness of this kind of approach, taking early action and letting ecosystems essentially "manage" themselves, is far superior to playing the expensive and unsure game of catch-up.

A major problem here, of course, is our limited knowledge of the ecology of populations and communities and the requirements of their constituent species, let alone the functioning of entire ecosystems. For the most part we are faced with saving islands of habitat amongst man-made and man-used environments. How big should these islands be and what should be their shape? What is the minimum critical size needed to sustain certain species? Ecologists are attempting to formulate answers to these and other questions, which are vital to producing paradigms on which to base effective action. It must be recognized that there are no simple answers, no matter how fervently they be demanded. Examples of attempts to analyze current ecological theory in the efforts of management include those of Diamond (1975), Duffey and Watt (1971), Myers (1976), Simberloff and Abele (1976), Sullivan and Shaffer (1975), and Wilson and Willis (1975). A fundamental work in most of these considerations is that of MacArthur and Wilson (1967).

Natural areas are also the base-line or control against which the effects of change can be measured. We cannot tell if the species diversity of a modified area is in decline unless we know what it was like before the modifications, or unless we have similar unchanged areas in which to measure diversity. We cannot determine whether population numbers are dropping as a result of our activities or through natural causes unless we can monitor populations in similar sectors unaffected by our activities. If all communities and ecosystems are modified, and none left

General Introduction -- Some Problems

in anything resembling a natural state, we have eliminated our yardsticks. We have also eliminated systems that might be needed as models for future habitat and community reconstructions.

The importance of comparative studies of experimental areas and preserves is recognized in UNESCO's Biosphere Reserve Program (Franklin 1977). One such reserve for monitoring the Eastern Forest Biotic Province is located in North Carolina, and currently consists of Coweeta Experimental Forest and Great Smoky Mountains National Park. The importance of unchanged areas as base-line indicators is also seen in the program of Research Natural Areas, some 300 of which are now established throughout the country.

So, while it is obviously too late for zero-base thinking on our most critically endangered species, it is not too late to make serious efforts to identify and preserve intact areas whose species are not threatened with extinction.

Some of the General Problems

It should be understood at the outset of this discussion that it is not our intention to make specific value judgements here. The biologists who participated in the Symposium on which this book is based recognized that their role was to address only the biological questions, and to consider other matters solely as they related to the objective facts of endangerment and extinction of plants and animals. We are, hopefully, supplying information to a public education effort, bringing data and responsible opinions to bear on a subject of importance to all. Failure to present these facts and articulate these opinions would be a dereliction of our public responsibilities. *The decisions affecting the ultimate fate of our biota will be based on expressions of preference and need, made by an informed citizenry acting through their elected representatives.*

The catalogue of causes of endangerment is, of course, very long, and all of us have at least a cursory acquaintance with many of them. They fall into four general categories. The first and greatest problem for most living things today is habitat degradation through physical changes, pollution, and eutrophication, and pre-emptive uses of habitat which are incompatible with the well-being of certain plants and animals. The second is introduction of alien species and transplants of native species. The third is direct extermination through excessive consumptive use of species for commercial, recreational, or other purposes. And the fourth is both direct and indirect extermination through pest and predator control activities. These categories obviously overlap somewhat, and their order of importance varies both in time and with the kinds of organisms involved. For example, Goodwin (1973) shows that 60% of the mammal taxa listed in a recent IUCN Red Data Book as threatened with extinction have been placed in jeopardy by direct reduction, and only 30% by loss of habitat.

Many of the consequences of deleterious activities are overt and need no further discussion here. This is neither the place for an extensive discussion of the causes of endangerment and extinctions, nor for a precis of the basic ecological principles which apply to populations and communities. Each mode of endangerment, however, has some important aspects that are not always straightforward, but which must be understood if intelligent decisions are to be made concerning our dwindling flora and fauna. It is some of these rather obscure ramifications of the problems that

will receive our attention. Furthermore, ecologists have identified certain characteristics which seem to be hallmarks of species vulnerable to extinction. Since these should become part of the working knowledge of concerned citizens and decision makers, they will be briefly presented as well.

Physical Habitat Destruction and Pre-emption

We all know that if a given habitat is seriously altered or used for purposes incompatible with the survival of biota, the result may be direct extermination or forced emigration of whatever makes up or occupies that habitat. Perhaps no distinction should have been made between emigration and extermination, since dispossessed creatures seldom survive for very long (Smith 1976). If these changes are extensive and persistent, as in the creation and management of monocultures, the long-term results may be at least locally severe. Whether this has any effect on species, as opposed to individuals or limited populations, will depend on the relationship between their distributions and the areal extent of damage. If endemic forms of limited distribution are involved the result may well be extinction of species or whole genera, or even, in rare cases, of entire families. It might be said here that an endeavor like tree farming, judiciously done and on a reasonable scale, can provide a partial solution to habitat and species loss by obviating some of the need to crop "natural" forests.

If physical disruptions are temporary and followed by conscientious attempts at reclamation, can we expect the natural community of an area to return in time, as is often suggested? If the land and water are not made toxic, it is not unreasonable to expect at least limited recovery since, given enough time, succession from relative simplicity to relative complexity is an ecological fact of life. The first thing needed for community repair, of course, is a nearby refugium to provide propagules or units of reproduction for replenishment. Even if these are available, however, there is no guarantee that a healthy community will eventually be re-established. For one thing, some species are sedentary, unable to move from even directly adjacent areas, and others, while able to move into new areas, simply will not do so. Perhaps more importantly, some current studies indicate that the future productivity of an area depends on the amounts and kinds of nutrients and other important chemicals available in the area. Maintenance of an adequate supply of these essential elements may require cycling and recycling through a living community (see Woodwell 1974). Thus, the absence of a diverse community may lead to unseen habitat deterioration, making it deficient or sterile in certain components needed for succession to occur. A great deal of research is being conducted on the important subject of recovery of disturbed areas (see Cairns et al. 1971, Chadwick and Goodman 1976, Curry 1971, Hill 1971, Hutnik and Davis 1973, and Lassiter and Cooper 1971). A 1976 "Annotated Bibliography on the Ecology and Reclamation of Drastically Disturbed Areas," listing over 590 titles, is available from the U. S. Government Printing Office, Washington, DC.

Disturbance of habitats sometimes leads to an indirect exterminating process, which is *hybridization* between species breeding at the same site. Under normal conditions there are reproductive isolating mechanisms which prevent this, but these can apparently break down when habitats are disrupted. The result is loss of genetic integrity, and

usually sterile offspring. Documented examples can be found in the literature on plants, amphibians, and fishes. Fuller reviews the endangerment of certain snail species by hybridization in modified habitats in the account of *Triodopsis soelneri* in the chapter on *Freshwater and Terrestrial Mollusks*.

Pollution

A major and pervasive cause of species endangerment is pollution, which comes in many guises. Pollution may be chemical, it may take the form of excessive siltation and turbidity, or it may be thermal, which usually involves the input of heat into aquatic systems. A *pollutant* may be generally defined as *any agent added to the environment which causes direct or indirect biological stress beyond that caused by natural forces alone*. Some pollutants are harmful in any concentration except mere traces, while others are apparently only deleterious in massive doses. The first type includes a number of chemical compounds, some kinds of radiation, and certain heavy metals like lead, mercury, and cadmium. Heavy metals and radiation occur in nature, of course, but in minute quantities known as *background levels*. Mercury, for example, can come from erosion of rocks containing cinnabar, a mercuric compound. Biological and ecological systems have adapted to these levels through millions of years of trial-and-error experiments. The problem now, however, is the relative flood of such things entering the environment, in quantities much greater than background amounts. Not only have the amounts of natural substances been greatly increased, exceeding the assimilative capacities of plants and animals, but organisms must now attempt to cope with a deluge of exotic synthetic chemicals that have never been encountered in all their long evolutionary history. The Environmental Protection Agency estimates that about 1,000 new chemicals enter the marketplace every year, and very many, if not most, subsequently find their way into the environment. Quite a few are very stable and persist for long periods. There is not enough time for most species to make genetic adjustments to these rapid environmental changes, and the inevitable result is elimination of at least the more sensitive groups. It must also be recognized that even supposedly minimal pollution can eliminate a population or reduce it to unsustainable levels if applied at critical stress periods when normal pressures themselves are severe.

There is an interesting paradox involved in the use of new chemicals to control target pest species. When first used they do a quick job of reducing the populations of these species, and may be of immediate benefit to mankind. But, few have been specific enough in their toxic action or mode of application to kill only the targets, and the result is a fairly broad spectrum of elimination. This eventually *favours* the target species by eliminating predators and competitors, since, in the absence of these constraints, the pests can rapidly evolve resistance to the chemicals. Such species are opportunistic, and characteristically have large, widely distributed populations containing a great deal of genetic variability. Every chemical kill-off, no matter how massive, leaves some survivors which are genetically resistant to the toxin or toxins used. With short generation times and great reproductive potential, they then breed rapidly and replenish their populations, and a greater percentage has resistant characters. Before very many generations have gone by, members of the target populations are no longer susceptible to particular chemicals.

It is a matter of 'natural' selection. A similar but not identical phenomenon, even more greatly amplified by very short generation times and high mutation rates, is seen in the development of dangerous microbes which are resistant to our standard arsenal of medical drugs. Genetic resistance to chemical weaponry, and absence or great reduction of natural competitors and predators, can combine to produce epidemics of harmful or undesirable organisms.

This phenomenon is germane to the problem of endangered and threatened species, since many of the predators and competitors of pests are in jeopardy as a result of control efforts, and so are other species, as will be discussed shortly. Recognition of the prevalence of this rapid adaptation capability on the part of pests is one factor leading to integrated or total systems methods of control. These combine biological controls, selective applications of degradable chemicals, and research to find or develop more species-specific pesticides. The total systems approach will certainly be of greater benefit to our general biota. The literature on this subject is rather extensive; see Debach (1974), Delucchi (1976), Huffaker (1971), Metcalf and Luckmann (1975), and Metcalf and McKelvey (1976). Gunn and Stevens (1977) also provides recent discussions.

Examples of pollutants which are only harmful at rather high concentrations are organic wastes, fertilizers, and detergents. Even small amounts may accumulate to harmful levels over a period of time if not susceptible to breakdown by living things (biodegradable), or degradable by non-biological processes. Organic wastes are, of course, highly degradable, but when forced on living systems in copious quantities the sheer volume can swamp the ability of these systems to handle them. In aquatic environments they, as well as fertilizers and chemicals in detergents, can stimulate plant growth by providing unnatural quantities of elements usually in short supply, like nitrogen, phosphorus, and carbon. This is called *cultural eutrophication*, and is generally prevented under normal circumstances by the fact that the limited availability of these elements, especially phosphorus (Schindler 1977), sets a limit on primary production. Superficially, eutrophication would seem to be a blessing, since we are used to thinking that increased production is an inherently good thing. Indeed it might be if it could be harvested and used, by animal or man, but this is not often the case. The excessive growths die and decompose, and in the process of decomposition large quantities of oxygen are used from the surrounding waters. If the loss of oxygen exceeds its replenishment the system becomes primarily anaerobic, and only organisms needing little or no oxygen can survive.

The entire matter of the effects of pollution on organisms, and ultimately on species, is quite complex. Some adult animals, for example, can survive high concentrations of toxins, while their young (or early developmental stages) may succumb to low concentrations. Thus, in order to assess the effects of pollution, all life history stages must be considered, on a long-term basis. Some migratory birds may carry sizeable latent loads of chemicals in their fat deposits where they do no visible harm as long as the birds are in summer or winter grounds. With the onset of migration, however, immediate energy sources drop, fat reserves are put into the metabolic machinery, and the once "safely stored" substances may become harmful to biochemical processes, and even lethal. This has also been shown in migratory bats (Geluso et al. 1976).

Sometimes single pollutants will have little or no effect on organisms, but when combined with others the effect is much more severe than would be the sum of the pollutants acting separately. This is known as a *synergistic* effect and, considering the numbers of new compounds constantly added to our environments whose tandem effects on life have never been explored, the possibilities for harmful synergisms are great and increasing. The complexity of pesticide residues is illustrated by findings such as those of Bartha (1969), who discovered that two herbicides applied in combination were transformed in soil to an unexpected hybrid compound.

A common argument often advanced to support certain levels of pollution is expressed in the slogan, "The solution to pollution is dilution." In other words, pollutants in low concentrations, very often those judged "safe levels," are not injurious to biota and the environment. This kind of thinking might be reasonable, even ignoring the fact that safe levels may not have been established by long-term experimentation for a variety of toxins under a variety of conditions, apply only to humans, are difficult to control, and are even more difficult to monitor, if it were not for two usually overlooked phenomena which make the dilution argument fallacious. First of all, and unexpectedly, living systems may affect pollutants in ways which increase their toxic effects. The biologically naive decision to dump mercury into Minamata and Niigata bays, Japan, was apparently made on the not unreasonable assumption that this heavy liquid metal would just slide into marine sediments and remain trapped in a permanent sink. Unfortunately, those responsible had not reckoned on the actions of bacteria which converted inorganic mercury to organic methylmercury, or on the bottom organisms which helped it get back into circulation. The organic compound entered the biological food webs of those bays, and eventually accumulated in the tissues of predators like swordfish and tuna by the process of *bioconcentration*, which is the second flaw in this argument.

Bioconcentration seems to be a primary mechanism for endangerment of species throughout the world. Even minute concentrations of pollutants in environments can be magnified up food chains, and top-level carnivores can accumulate loads heavy enough to interfere with metabolism and reproduction. This is well documented in hawks and other predators, as recourse to the references provided in many of the accounts in this book will show. Some predatory diving birds are known to have accumulated chlorinated hydrocarbons to concentrations 100,000 times that of the water in which they fed, and the demise of the Brown pelican in our Gulf states has been attributed to the effects of intolerable loads of these chemicals on reproduction. Carnivorous human populations, the ultimate predators, may be the greatest concentrators of all. It would therefore be no surprise to learn that certain populations of human beings are endangered from bioconcentration of harmful chemicals.

That pesticide loading can be reversed, however, is seen in a number of findings. Anderson et al. (1975) reported improved fledging rates in certain California Brown pelican populations correlating with better egg-shell condition and egg survival as DDE contamination declined in anchovies, their major food. Johnston (1974) found a progressive decline in concentration of DDT and its metabolites in migratory songbirds for the period 1964 to 1973, as usage of DDT in the United States decreased.

Thermal pollution is a relatively recent phenomenon, and its effects on biota are only now receiving experimental attention. A number of papers have assessed the influence of thermal discharge on aquatic

fauna, including Stauffer et al. (1975, 1976) for distribution of fishes in the vicinity of thermal discharges from a fossil fuel electric generating plant on the New River in Virginia. The results of a symposium on thermal ecology can be found in Gibbons and Sharitz (1974). The eventual problems for plants and animals are similar to those caused by new chemicals. "Many unique thermal environments have been created by the effluents from electric power generating plants. Since these environments are of recent origin, populations of fish have not yet evolved which can efficiently utilize them." (INHSR 1976). This is probably not just true of fishes but of all major aquatic organisms. Interestingly, the only known occurrences of several species of marine fishes in North Carolina are from the immediate vicinity of the Brunswick Power Plant just north of Southport (*Marine Fishes*, this volume).

Pollutants, like other forms of habitat degradation, affect species populations and communities as well as individuals. This may be through direct, extensive toxic effect, or indirectly by elimination of the food base. Sensitive individuals, to be sure, are the first to be lost, and the loss of a few individuals is usually inconsequential to a species. But, repeated deletions of single animals or plants can eventually result in changes in size and age structure of populations which may be of sufficient magnitude to damage reproductive success. Such changes, of course, are of great concern at the species and subspecies level. This is especially true of vulnerable species displaying the characteristics to be discussed later.

Introduction of Alien Species

Another major problem which can lead to extinction of native flora and fauna is the introduction of exotic species. Although not all such introductions are harmful, and some exotic plants are obviously quite beneficial to agriculture, some of our native plants and animals are being replaced with species of little value and perhaps extensive harm to natural communities. South Florida has been so hard hit by alien introductions that it was described as "a biological cesspool of introduced life." (Lachner et al. 1970). The overall problem is not limited to introductions of foreign species, but includes the moving of animals from one place to another within our national borders, an activity known as *transplanting*. But, whatever the origins, the results of improper releases may be destruction of natural communities and consequent demise of a commercial, recreational, or cultural resource.

As an index of the potential magnitude of the problem, the U. S. Fish and Wildlife Service reported that in 1968 alone there were over 64 million tropical fish, 170,000 amphibians, nearly 2 million reptiles, almost 500,000 birds, and 140,000 mammals imported into the United States (*in* Lachner et al. 1970). Over 100 million fish were imported in 1970 (*in* Courtenay and Robins 1975). A 1972 ban on bird imports, precipitated by an outbreak of a severe avian disease (Clapp 1975), was amended in late 1973, and only 30,738 birds were declared in 1974 (Greenhall 1977). Probably few of the animals brought into this country find their way into our environments, of course, and most could only survive in certain areas if they did. Nevertheless, some have experienced planned releases, and some were introduced as discards, escapes, or by careless management, which is almost inevitable where such large numbers are involved. As a result at least 25 foreign species of fishes are known to have established breeding

General Introduction -- Alien Species

populations in this country, and many other releases are suspected of being well entrenched.

Introduced exotics or native transplants can affect species diversity through grazing, predation, competition for resources and space, introduction of parasites (Courtenay and Robins 1975), and hybridization (Lachner et al. 1970). They can also damage local populations and communities by severe habitat alteration and disruption. A good example of this is the ubiquitous Carp of Asia, whose introduction here from Europe in 1831 has burdened us with a permanent pest. Some states have spent considerable sums in futile attempts to control this fish. Problems associated with introductions into aquatic environments, and recommendations for solutions, were discussed in a Conference on Exotic Fishes and Related Problems (Stroud 1969). Alien animals need not be directly harmful to native animals and plants in order to assist in their demise. Many introduced species, finding open niches in communities devoid of predators and competitors, rapidly expand their numbers to pest proportion. Efforts to control these alien pests can have inadvertently harmful effects on non-target native species.

On the local scene several problem introductions, aside from such prominent cases as agricultural pest insects and birds like the Starling and English sparrow, are worth mentioning. Wild boars, introduced into the North Carolina mountains from Germany about 60 years ago and escaped from a hunting club at Hooper Bald (Bratton 1975), have increased to such numbers that they are directly destroying plant and animal life, some quite rare, and competing successfully with other species in the Great Smoky Mountains National Park. Efforts to control these animals and diminish their effects on local biota now involve expenditures of time, energy, and money (Bratton 1974, 1975). The Monk parakeet, an agricultural pest introduced from South America, is increasing its numbers and range in the eastern United States. There were recent sightings of this bird in South Carolina, and breeding colonies are known in several states, including Virginia and possibly Maryland. It was reported to be nesting in the vicinity of Asheville, Buncombe County, North Carolina, in 1972-73, and seen more recently in other parts of the state. A researcher from the State Museum was unable to find the bird near Asheville in March, 1977. What effect it might have on the local avifauna if it becomes established is unknown, but it has the reputation of being an aggressive species. The Asiatic clam, *Corbicula*, suspected as a prime factor in the demise of certain freshwater mussels in Gulf drainages, has been found in Atlantic drainages in the past several years. As reported in the chapter on *Freshwater and Terrestrial Mollusks*, it is known to occur in Lake Waccamaw and a few other places in North Carolina, which could prove disastrous for the unique molluscan fauna of the Waccamaw basin, and perhaps elsewhere. The prolific Kudzu vine, another native of the Orient, was introduced into North Carolina about 25 years ago to control erosion, and has run rampant. It is now considered a danger to native plant species. There have been other introductions here, but these should suffice as examples of good intentions gone wrong.

Accurate predictions of the effects of non-native species on given communities are not yet, and may never be, possible. Most ecologists would undoubtedly agree with Laycock's admonition (1966) that, "Release of wildlife into territory foreign to it involves, not a calculated risk, but a risk too great to calculate." Game managers would, as a wildlife

biologist put it (Scheffer 1974), "be wiser to improve the environment of the native species -- those that have adapted through centuries of time -- than to be dazzled by the presumed advantages of creatures from other lands."

These comments are not to be construed as in opposition to the restoration of animals and plants into congenial areas which they formerly occupied but from which they are now absent, which is an entirely different matter. Transplant reintroductions into depleted parts of historic ranges are an integral part of management planning for some endangered species, as can be seen in the projected efforts of Recovery Teams. Even these movements, however, must be based on sound research, since transplants from the wrong populations can be futile at best, harmful at worst.

Consumptive Wildlife Uses

Hunting and fishing, especially for commercial purposes, have played their role in endangerment and extermination, but this aspect of the problem is now far less severe than others. There is little question that the demise of certain forms, like the Passenger pigeon, eastern populations of the Elk, and local populations of Deer, Beaver, and other game species, can be attributed primarily to large scale hunting. Food hunting and indiscriminate commercialization aided in the extermination of more bird species from North America in a 200 year period than were eliminated from any similar-sized area in the world (Greenway 1958). All were specialized endemic species. Like all problems which are basically ecological, however, extermination of a species is a very complex phenomenon, and it is difficult to assign sole responsibility to any single activity. For example, while market gunning may have seriously depleted populations of the Passenger pigeon, other activities, like forest clearing, and the reproductive ecology and behavior of the animal itself, probably administered the *coup de grace* to the species. Hunting and fishing are generally so well regulated in this country today, and fish and wildlife management is making such significant strides, that there is decreased concern for most primary game species. This is not to suggest that game protection and management programs are without their faults, and there appear to have been some specific failures (for example, see Geis et al. 1971 on the Black duck). Predator control, sometimes undertaken in the name of game improvement, has been the cause of environmental degradation in certain areas. There is always great danger and uncertainty in tampering with systems that are little understood, and management of those systems for the benefit of a few species is often detrimental to some of the rest. An eloquent and constructive critique of our wildlife programs, from the vantage point of a seasoned insider, is provided by Scheffer (1974).

Despite these considerations, however, there is no escaping the fact that in the early years of this century the survival chances of all of the major species of wildlife were slim, as reflected in Hornaday's (1913) volume on vanishing wildlife and its preservation. They would all have been placed on an endangered species list had there been any such thing. Egrets and herons were on the brink of extinction from plume hunting, but made a dramatic comeback when this activity and its market were made illegal and the laws enforced. Ironically, they may now be threatened in particular areas by habitat destruction and probably pollution. The Wood duck, perhaps the biggest success story of all in game species management, was nearly extinct in 1915, and is now one of the most common breeding

waterfowl in the eastern United States.

A more contemporary criticism sometimes leveled at wildlife programs is that they pay insufficient attention to non-game species, despite the fact that these species may be more important cogs in an ecosystem wheel than game species, and vital to game survival. This has long been an economic matter, with the rationale being that studies and protection programs for "wildlife" (i.e., game) are supported by monies from hunters and fishermen, thus only the species serving as a resource for this constituency are of legitimate concern. This attitude is changing in many areas. Although the intensity of commitment varies from state to state, wildlife management and conservation programs are paying more and more attention to non-game species, and a broader based "ecosystem approach" is emerging. Some of the clamor to have this done is coming from those hunters and fishermen who see their activities more as a total experience in nature than a trip to the meat market. Changes in funding, however, have been slow to follow changes in philosophy, and special (often ineffective) programs to raise non-game funds seem to be the rule rather than the "democratization" of expenditures by recourse to general funds. Graul et al. (1976) comment on one state's (Colorado's) approach to this matter.

Except for some glaring examples, scientific and educational collecting are fairly judicious, and the relatively small numbers taken by usual collecting methods can scarcely make serious inroads into most natural populations. These activities, especially where efficient sampling methods using biocides are employed for collecting vertebrates, are controlled by permit systems. Problems have existed, however, particularly with several vertebrate species which have very limited ranges (see Jordan and Mount 1975). Collecting at *type localities*, which are usually the sites from which the first or perhaps most typical specimens of a species were taken and described, has also been too extensive in some cases. The Marine Invertebrate Committee herein indicates that excessive take for educational and scientific purposes is a problem for two species of marine polychaetes, a commensal clam, and several gastropods of North Carolina waters. Pressures against overzealous collecting, exerted by professional groups and within the ranks of the scientific community, have greatly increased in the past several years, with nearly all appropriate biological societies issuing statements or passing resolutions aimed at discouraging these activities. Some major journals will not accept papers dealing with endangered and threatened species unless proof is offered that the research was conducted under proper permits, or prior to their identification as species in jeopardy.

Limited collecting by and for hobbyists is still a serious problem for many species, with good examples being some turtles and cacti. The pet value of the Bog turtle, reflected in the exorbitant prices paid for this species, were at least partially responsible for its legal protection in some states (Bruce, this volume; Cooper et al. 1973). Certain cacti which fetch fancy prices from plant fanciers have suffered greatly from commercial activities (Benson 1975).

Extensive exploitation of commercially important species is a much greater problem. As Hardin (1968) pointed out in his now classic essay, this is particularly true where the resource resides in common grounds. Here no jurisdictional arguments can be made to establish laws, or appeals to reason made for curtailment of take. A well known example is resources of the sea. Stocks of many of the most important marine fishes are so

depleted that economic survival of the industries which depend on these species is in jeopardy. International agreements are in effect for some species, but these are easily ignored. The plight of the great whales is a well known story. Six species which have been found in North Carolina waters are now on the federal endangered list.

Characteristics of Vulnerable Species

Biologists researching the problems of endangered and threatened species have attempted to identify characteristics of those which appear to be particularly vulnerable to extinction processes. One purpose, of course, is to establish models for predicting which species are likely to be most seriously affected by change. If such predictions prove possible, particular care can be advised for these plants and animals and their habitats. Although the analysis is incomplete, the following are some population and behavioral characteristics displayed by these species.

Sensitive species usually inhabit the more stable environments, where fluctuations in climate and other factors are not extreme and natural mortality is low. Their populations exhibit dynamic equilibrium in numbers and structure, with little variation. They also appear to have greater longevity and longer generation times, deferred reproduction, and few offspring, while survival rate of both offspring and adults is high. Unlike opportunistic species, they have little or no ability to exploit transient and changing environments. Species displaying these qualities are known to many ecologists as "K-selected" species or "K-strategists" (Miller and Botkin 1974, Pianka 1970), as opposed to opportunistic forms, which are known as "r-strategists." The derivation of these terms can be found in MacArthur and Wilson (1967), and criticisms of the concept can be found in Nichols et al. (1976), Wilbur et al. (1974), and elsewhere. K-strategists, by whatever name, are clearly at a disadvantage where environments are severely disturbed and population numbers may experience drastic reductions.

Big animals that feed high on the trophic pyramid, like panthers, wolves, predatory birds, and others, require lots of living and hunting space. They have low reproductive rates, and, as species, cannot tolerate habitat decrease or pressures. When reduced in number they are slow to rebound. Endemic species with very restricted distributions and rigid habitat requirements are in danger, although they may be common where found. Local examples include quite a number of the plants discussed in the chapter on *Vascular Plants*, like Oconee bells, some pyxie mosses, and Venus' fly-trap; the Neuse River waterdog discussed in the chapter on *Amphibians and Reptiles*; the endemic fishes and mussels of Lake Waccamaw discussed in the chapters on *Freshwater Fishes* and *Freshwater and Terrestrial Mollusks*; and certain montane insects discussed in the chapter on *Freshwater and Terrestrial Arthropods*.

Species that are colonial nesters or aggregate for other reasons, like marine turtles, some birds, and some bats and marine mammals, are also highly vulnerable. Concentrations of adults, eggs, and young can be destroyed *en masse* by development, vandalism, or introduced predators. In North Carolina there are a number of coastal birds that are relatively common and widespread, but which at breeding time put all their eggs into a few baskets, so to speak, in localized rookeries. Their apparent abundance along the coast during most of the year might mislead people to think they are not in trouble, but the habit of colonial nesting makes them quite vulnerable during breeding. The extinct Passenger pigeon, it might be

General Introduction -- Basic Problem and Values Involved

noted, was a communal nesting land bird (Schorger 1955), as was the Great Auk.

Migratory species can also be subjected to unusual pressures, at both ends of their routes as well as in between. Drastically altered conditions in summering or wintering grounds can be disastrous. Disruption of winter habitat is probably the prime cause of declines in both Kirtland's and Bachman's warblers, which have the most restricted winter ranges of all North American migrants (Mayfield 1960, Meanley 1971). Bachman's warbler, not seen in North Carolina in recent years but reported in South Carolina, winters in the woods of western Cuba, which have largely gone or are going to sugar cane. Kirtland's warbler, reported here as a migrant by one observer, winters in the pine woods of the Bahamas, which are suffering the effects of increased development. This bird is also affected in its summer range by expansion of the range of the Brown-headed cowbird, a species which is a nest and brood parasite (Radteh and Byelich 1963).

The Basic Problem

Almost all of the major problems now faced by our native fauna and flora, and ultimately ourselves, are a result of the pressures of an expanding population and increased per capita demand for economic productivity, and other necessities and amenities of life. Over five million people now reside in North Carolina, as compared with 394,000 in 1790, and this population is increasing steadily (Catau et al. 1975). Demographic projections call for a total state population of between 6 and 6.5 million by the end of the next decade, and perhaps 7.3 million by the year 2000 (Clay et al. 1975). Since most of the population addition is urban oriented, an inevitable increase in land consumption is occurring and expected to accelerate at a rate exceeding the rate of population growth. As Browning and Parker (1975) indicate, much of the fastest growth is taking place in areas that have characteristically been the least urbanized, areas that "typically are ill prepared to guide and direct growth." This unplanned and uncontrolled land use, with its consequent habitat destruction, pre-emption, pollution, and deletions of biota, is the basic reason why many of our plants and animals are in jeopardy.

The Values Involved

The evidence clearly indicates that something quite far removed from a natural situation is occurring with respect to extinction and endangerment of species, so we must now ask why it has caused so much concern. The question, put succinctly, is "So what?" This is a legitimate question for a number of reasons, not the least of which is the fact that a lot of time and energy, and some public money, have been expended in behalf of endangered and threatened species, and the effort is increasing. Perhaps the primary reason for this question lies in the fact that preventing any further erosion of natural diversity will require some basic changes in time-honored public attitudes, and a searching look at the way we live. The question can be answered in a variety of ways.

Indicators of Environmental Quality

It does not behoove us to lose sight of the fact that we are biological organisms, and, as such, quite dependent on a healthy world with its communities and ecosystems functioning properly. We do not stand

above the consequences of degradation of the earth's life-support systems, and cannot afford to ignore the fact that the forces operating to jeopardize other life may also be affecting our own, in ways that we do not yet understand. Extinctions of plants and animals, and the changes in their population and community structures which lead to endangerment, are good indicators of malfunctioning. And it isn't necessarily "valuable" species that inform us of these changes, either. Ehrenfeld (1976) reminds us that "the traditional economic value of a species is of no significance in determining its usefulness as an environmental indicator." Biotic indicators of environmental quality are discussed in a number of publications, and several chapters in Thomas (1975) provide useful information and references.

The fact that we are quite different from other organisms should not lead us into making false assumptions about ourselves. As Jackson (1976) points out, it is the *similarities* between ourselves and other forms of life, and not the differences, that make them valuable as instruments for monitoring environmental quality and telling us about *our* current and potential problems. After all, from a particular biological viewpoint, we are simply different manifestations of the same small set of amino acids that goes into the composition of all life. Basic biochemistry is basic biochemistry, whether we like it or not, and will not be ignored. How some members of our species get the impression that we are divorced from the rest of nature is a considerable mystery to biologists.

Present and Potential Uses

In addition to "life-support system" considerations, we can enter other blatantly selfish arguments against eliminating species. One of the more widely promulgated of these, although sometimes questioned, has to do with human uses of a great variety of organisms. Basic life processes are indeed similar, but every species is biochemically unique in many respects, with attributes not possessed by other species. If we keep on eliminating animals and plants at an ever increasing rate, we run the obvious risk of losing many forms of actual or potential benefit. Despite the fact that most such species are now at the "non-resource end of a utility continuum" (Ehrenfeld 1976), elimination of species is a gamble which seriously erodes human options, not necessarily for today and the immediate tomorrow, but particularly for future generations to whom we have non-negotiable responsibilities. Some observer whose name is not immediately at hand noted that hindsight is always perfect vision, but none of us has 20-20 foresight. Whatever values our native plants and animals possess can only be realized if we maintain them for study, in communities that are as normal as possible.

We have not yet learned the lesson that seemingly insignificant species can suddenly become very important to human health and well-being. This is despite the fact that history is so replete with excellent examples, many of them serendipitous, that there is no need to either inflate or seriously question these claims. Jim Williams mentions the oft-cited case of penicillin, the vital antibiotic which originates from a mold destructive of citrus plants. In the same line we might mention the other lowly microbes which produce such medicinal drugs as streptomycin and tetracycline. These things do not originate in medical laboratories, any more than food originates in supermarkets. This is not an attempt to suggest that any microbes or molds are endangered species (although it is

likely that this possibility has received little attention), but to point out that insignificant living things whose welfare receives little attention may be very utilitarian in appropriate circumstances.

The Smithsonian Institution report on Endangered and Threatened Plants (1974) states that an estimated 50,000 new alkaloids, including possible cancer medications, are potentially discoverable in plants. Altschul (1973) mentions probable uses for more than 5,000 little known plants. Several localized endemic plants, recommended for inclusion in the federal lists, are being tested for oils with industrial potential, yet may be destroyed by relatively small-scale habitat destruction. It is no secret that many commercially valueless plants, especially legumes, are important nitrogen fixers, and without them our usable budget of this element so necessary to life would be less than adequate.

Although it is fairly widely appreciated that many marine species in trouble represent great and direct value to a large human population in a protein deficient world, few of the known marine animals of the world have been studied for chemical compounds of importance. Yet many compounds from some marine organisms that have been studied "have inhibitory effects on a variety of microorganisms that cause disease in man." (Ruggieri 1976). This author reports that certain marine organisms contain substances with "antiviral, antimicrobial, tumor-inhibitory, anticoagulant, cardioactive, or neurophysiologic properties." A poison called nereistoxin, isolated from a species of polychaete worm, is currently being used to make a pesticide to control a number of insect pests, including strains resistant to organophosphates and organochlorides. Judging from the number of papers published in recent scientific journals reporting basic neurological research on a marine mollusk known as the Sea Hare, *Aplysia*, this is an invaluable organism in such research. Yet most people have never heard of the Sea Hare, and many would not be concerned if it were endangered, despite the fact that we are reaping benefits from its use as an experimental animal.

A compound has recently been isolated from a group of millipeds which may have potential as a pest repellant. Leeches produce a useful blood anticoagulant, and the venoms of spiders, snakes, and scorpions are important to several areas of medical research. Certain snails are producers of medically useful compounds, including antibiotics, yet many snails, of which two species occur in North Carolina, have been proposed for the federal endangered and threatened species lists.

And, of course, it should not be necessary to point out that any species of use to humankind supports, or will come to support, segments of the economy.

The catalogue of human uses of obscure, even "horrible," organisms is long, and doubtless will become much longer if we hold our options open by refusing to accept a careless attitude toward biological impoverishment. This should be one of the more compelling of the homocentric arguments advanced in favor of species diversity. Without that remarkable attribute 20-20 foresight, the only way to guarantee a better future for the human species is for all of us to adopt a more prudent, if not altruistic, philosophy where the plants and animals that comprise natural communities are concerned.

Diversity and Stability

Another answer to the question "So what?" has to do with the possible relationship between the diversity of natural systems and the stability of those systems. Although the concept is still being debated, many if not most ecologists believe that stability -- the ability to survive environmental change and recover from perturbations -- depends on maintaining complex systems high in species diversity. Several recent books and symposia address this idea, including May (1974), Usher and Williamson (1974), and Woodwell and Smith (1969), as do a number of papers and chapters in more general publications (Goodman 1975, and others). A complex community represents thousands of years of trial-and-error adjustments between its species. If its "delicate balance" is disturbed by eliminating a species or two, the reverberations may be felt throughout the community for a long time. Elimination of a species is never a simple thing, since all forms in a community are in many ways interdependent. The net result may be great simplification and consequent instability.

This and other broad ecological reasons for our concerns are sometimes difficult to accept because they are abstract and rather much removed from immediacy. Nevertheless, that they are being accepted is indicated by Talbot (1974), who reports the decision of the New York State Court of Appeals to uphold a law protecting depleted and endangered wildlife "on the grounds that it was necessary for the State to protect the animals not only for their aesthetic value and for scientific study but for their key ecological role."

Quality of Life

There are other kinds of arguments for maintaining diversity and fostering a strong concern for endangered and threatened species, which may be subsumed under this general heading. Many people, and the numbers are increasing every year, feel that the quality of life is greatly diminished as animal and plant communities undergo progressive simplification. This attitude is often scoffed at, and called elitist or "unrealistic." Its proponents, who often suffer such pejoratives as "dicky-bird watchers" and its ilk, are accused of indulging in luxuries at the expense of progress designed to benefit all instead of just a "privileged few." Over and above the fact that progress is in the eye of the beholder, definable in many ways, aesthetic and recreational concerns are quite legitimate, especially in a democracy. Those who argue purely for consumptive uses of native plants and animals are going to have to accept, as Scheffer (1976) points out, that a great many Americans "have a spiritual or emotional interest in wildlife which is as strong and as legitimate as theirs." These interests in wild plants and animals may be more firmly grounded in reality than arguments against them. Claims that such uses of the outdoors have direct mental and physical health benefits for humans have been made (Iltis et al. 1970), and the psychological and physiological aspects of the matter should get a great deal more investigative attention than they have so far received.

Uses of wildlife can be thoroughly non-consumptive and still bear a fair share of the economic burden. Consider that bird watchers alone contributed some \$500 million to the Gross National Product of the United States in 1974, a far greater expenditure than that made for most, if not all, consumptive uses of wild birds (DeGraaf and Payne, *in* Schick et al. 1976). The same is probably true of non-consumptive uses of wild flowers

and other plants, and some animals other than birds, although it would be more difficult to quantify. Tens of millions of people find recreation in nature walks, photography, and related activities, and the increasing use of our national parks and other wild and scenic areas is at least partial testimony to their willingness to pay for these interests. Membership in nature and conservation organizations has experienced considerable growth in recent years, while the number of sport hunters (an example of at least primarily consumptive users) either declined or increased only slightly. Reed (1972), addressing the need to give new attention to non-game species, said, "It is apparent that not enough has been done or is being done to satisfy the public's interest in the non-game species and non-hunting aspects of game species. Some recreation specialists predict that interest in this type of outdoor recreation will in the future exceed the demand for consumptive uses of these resources, if indeed it hasn't already done so."

Photographic safaris and other organized wilderness experiences are now big business. While such activities have a certain destructive potential, if carefully controlled and limited they can be economically important without being ecologically harmful. So can similar activities on a lesser scale.

An interesting viewpoint is expressed by Ehrenfeld (1976), who suggests that the way to avoid the problem of trying to conserve non-game species by assigning them unknown or unrealized economic values "is simply to identify the *non-economic* values inherent in all natural communities and species and to weight them at least equally with resource values." This, he recognized, will require changes in cultural attitude. Such changes are obviously in the making.

Other Values

Two largely overlooked values of "bird-and-beast watching" have been articulated by Scheffer (1974). One is the fact that this activity "yields a harvest of inspiration." Animals and plants, including quite a number of species now extinct or considered endangered, provided the source materials for fine works of art. The paintings of such old masters as Audubon, Fuertes, Gould, and Alexander Wilson, and those of such contemporary artists as Ray Harm, Richard Sloan, Guy Coheleach, and Don Eckelberry, owe their existence to intimate and long observation of nature. We should also include outstanding nature photographers in this company. And, of course, such art is not only an aesthetic resource but an economic one as well.

The other overlooked value indicated by Scheffer is the importance of nature watching to our symbolism. Our national symbol is a predatory bird. Every state has at least its official bird and plant, and some have official or quasi-official state insects, crustaceans, mammals, and other creature symbols. North Carolina has a state tree (Pine), flower (Dogwood), mammal (Gray squirrel), bird (Cardinal), and sea-shell (Scotch Bonnet, a marine mollusk). These symbols express certain values, too easily ignored or forgotten, that stem from close association with nature somewhere along the line. Animal and plant symbols are also an integral part of the mystique of many other aspects of contemporary life (for better or for worse!), including our literature, music, lore, place names, advertising, athletic teams, and our very language. The legalities of preservation of symbols important to our national heritage are discussed by Coggins and Hensley (1976).

Smith (1976) invokes the "awesome finality of extinction" as a major factor contributing to the growing interest in the preservation of endangered species, where the elimination of anything unique, whether a treasured work of art or a species, is irrevocable. He sees deletion of a species as "loss of a cultural artifact," in addition to other aspects of such a loss.

Thousands of people, and perhaps tens of thousands, view the extermination of species as an ethical issue. Other forms of life, they insist, have a right to exist over and above any claims that we may make on their usage, consumptive or otherwise. The British ecologist Charles Elton (1958) notes that, "Some people will believe this even when it is quite dangerous to themselves."

Wilson and Willis (1975) provide a summary perspective in arguing for an ethic of organic diversity. This ethic derives from the fact that we are the "self-appointed but still profoundly ignorant" stewards of the earth and its life, and have "scarcely begun to conceive of the possible benefits that other organisms will bring in economic welfare, health, and esthetic pleasure."

What Is Being Done?

To paraphrase Elton (1958), man does not live by gloom alone. Are there glimmers of light at the end of the long tunnel of species deletions? The answer is a qualified yes. We've come a long way since the careless days of just a few decades ago. This is true in both federal and state legislation and law enforcement, and, to a lesser degree, in knowledge of the phenomena involved, general awareness, and development of at least an embryonic ecological ethic. But, of course, we still have a long way to go, especially with respect to our understanding of the composition and functioning of natural ecosystems. Much more effort is needed, also, in making educational use of existing knowledge on behalf of our flora and fauna. There are still far too many people with only a superficial understanding of the nature and extent of the problems concerned. As Hopson (1976) indicates, most public attention has been brought to focus on eagles and bears and other such creatures "that are closest to our anthropomorphic hearts," while the mundane and unimpressive remain unchampioned. "Their very obscurity," she says, "is an extinction force as pressing as pollution, commercial exploitation or the destruction of their habitat." Research, and education based on this research, must receive much more of our attention. This theme, of the need for further research and education, reverberates through the chapters of this book.

General Reviews

Recent reviews of some historical phases in general wildlife conservation, the philosophy of preservation, and the procession of federal legislation related to conservation, are provided in Borland (1975), Coggins and Hensley (1976), Hickey (1974), and Smith (1976). Some important older contributions are the classics of Carson (1962), Leopold (1933, 1949), Marsh (1894), Osborn (1948), and Vogt (1948). Other pertinent works include those of Darling and Milton (1966), Dasmann (1968), Nash (1968), Shepard (1967), and Trefether (1961).

The legislation involved includes the Lacey Act of 1900, which gave the government control over the importation and interstate traffic of

General Introduction -- Federal Involvement

foreign species; the Migratory Bird Treaty Act of 1918; the Bald and Golden Eagle Protection Act of 1940; the Pittman-Robertson and Dingell-Johnson Acts which provide for the distribution of certain funds to states for wildlife and fish restoration; the Fish and Wildlife Coordination Act of 1958; the Wilderness Act of 1964; the Land and Water Conservation Fund Act of 1965; the Anadromous Fish Conservation Act of 1965; the National Environmental Policy Act of 1969, which includes provisions for considering the effects of major projects on endangered species; and the Marine Mammal Protection Act of 1972. The United States ratified the Convention on International Trade in Endangered Species of Wild Fauna and Flora in 1973, and it came into force on July 1, 1975.

Federal Involvement With Endangered Species

Federal involvement specifically with endangered and threatened species began around 1964 (Schreiner and Ruhr 1974) and led to the Endangered Species Preservation Act of 1966, which listed 72 entries as native endangered species. This was followed by the Endangered Species Conservation Act of 1969, a year which also saw the beginnings of a considerable burgeoning of public interest in the whole topic of environmental degradation. Congress officially approved an endangered species program as a line item in the fiscal 1973 budget of the Bureau of Sport Fisheries and Wildlife, and not long after passed the Endangered Species Act of 1973 (Public Law 93-205), effective December 28, 1973. This latest Act covers all animals, adds a Threatened category, and, for the first time, gives plants some of the consideration they have long deserved. It also provides not only for species and subspecies, but separate animal populations as well, to protect unique or disjunct groups, and new, undescribed forms.

As of November, 1976, there were 35 U. S. mammals, 65 birds, 8 reptiles, 4 amphibians, 30 fishes, 22 bivalves, and 6 insects on the federal endangered species list, and a single mammal and bird, 4 fishes, and 2 insects listed as threatened. The following listed species occur, probably occur, or once occurred and may still occur, in North Carolina or its offshore waters:

- Gray bat or Gray myotis, *Myotis grisescens*
- Indiana bat, *Myotis sodalis*
- Blue whale, *Balaenoptera musculus*
- Finback whale, *Balaenoptera physalus*
- Sei whale, *Balaenoptera borealis*
- Humpback whale, *Megaptera novaeangliae*
- Right whale, *Eubalaena glacialis*
- Manatee, *Trichechus manatus*
- Panther, *Felis concolor* (cougar and/or coryi)
- Bald eagle, *Haliaeetus leucocephalus*
- Peregrine falcon, *Falco peregrinus* (anatum, tundrius)
- Red-cockaded woodpecker, *Picoides borealis*
- Bachman's warbler, *Vermivora bachmanii*
- Kirtland's warbler, *Dendroica kirtlandii*
- Shortnose sturgeon, *Acipenser brevirostrum*
- Atlantic ridley, *Lepidochelys kempi*
- Atlantic hawksbill, *Eretmochelys imbricata*
- Atlantic leatherback, *Dermochelys coriacea*
- American alligator, *Alligator mississippiensis*

Another 47 animals, and approximately 1,850 plants, have been proposed in the *Federal Register* for listing. These include 2 sea turtles, a freshwater fish, 2 butterflies, 2 snails, and a number of plants known to occur in North Carolina.

Jurisdiction for the Endangered Species Act lies with the Departments of Interior and Commerce, with Commerce having responsibility for marine mammals, Interior for most non-marine animals, and the supervision of other species being resolved between the two agencies. The Act calls on all federal agencies to carry out conservation programs, and to assure that other agencies involved in actions *authorized or funded by them* do the same. This provision could also conceivably involve private lands supported in some part by federally funded incentives and assistance programs. Cooperative management agreements with state governments are encouraged in the interest of expanding regulatory powers and research capabilities, and the federal government will provide funds on a matching basis to states which give protection equal to or greater than that required under the federal Act. Fifteen cooperative agreements have been signed, and the North Carolina Wildlife Resources Commission is currently in the process of completing such an agreement with the U. S. Fish and Wildlife Service.

Although the 1973 Act emphasizes take (direct reduction), which may not currently be the major problem in the process of endangerment of most species, Section 7 addresses the determination of *Critical Habitat*. This has been defined as "the area of land, water, and airspace required for normal needs and survival of the species." The needs are those of space for growth, movement, and behavior, food and water, sites for breeding and rearing offspring, cover, and other biological or physical requirements (see *Federal Register* 40:17764-17765, April 22, 1975). Schreiner (1976) states that this is viewed as a "tool to help save and restore species, not a weapon to hinder economic or social progress." The controlling agencies recognize that not all types of land use are incompatible with the survival of endangered and threatened species. As of November, 1976, seven designations of Critical Habitat had been made and five others proposed. Section 5 of the Act authorizes acquisition of habitat with funds made available through the Land and Water Conservation Fund Act, and, according to Williams (1976), "To date more than 40,000 acres of habitat for 11 endangered species has been acquired at a cost of approximately 13 million dollars."

There are a number of major differences in the way the Act treats animals and plants, which are discussed by Baker and MacBryde (1976). For one thing, the taking of endangered plants is not prohibited. For another, plants must be included in the Appendices to the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Appendix II of the Convention includes the entire orchid and cactus families, and Ginseng, which, like many of the orchids, is on the North Carolina list proposed in this volume. Also, there is some question as to whether the cooperative agreement provisions apply to plants. A number of plant lists have been published as a "Notice of Review" in the *Federal Register*, but to date no final rulemaking on the Smithsonian Institution (1974) proposal has appeared. Thus, no United States plant species is yet officially considered endangered or threatened at the federal level.

The 1973 Act is a far reaching piece of legislation, but is not without its detractors, even among those who are in strong agreement with its

aims. For one thing, there seems to be little specified control over activities other than taking (and even that is questionable) which can seriously affect large concentrations of endangered species on private lands, although the *intent* of the Act is to include everyone subject to the jurisdiction of the United States. Also, its emphasis on controlling take of endangered species, even with permit provisions, has the effect of hindering legitimate scientific research of value to the species involved. Recent changes in the permit handling process may alleviate this problem. Some critics suggest that species are proposed for listing without sufficient evidence, although this difficulty is ostensibly solveable in the protracted review process. Miller (1975), for example, questions the advisability of proposing a number of butterfly species, two of which occur in North Carolina and are discussed in the chapter on *Freshwater and Terrestrial Arthropods*. Criticisms and discussions of the Act can be found in Coggins (1974) and Lachenmeier (1974). Coggins and Hensley (1976) specifically address the vulnerability of the Act from a constitutional standpoint, and the constitutional power of Congress to protect wildlife.

The legal power of the Act was reinforced by a January 31, 1977, unanimous decision of the U. S. Court of Appeals for the Sixth District, which permanently enjoined the Tennessee Valley Authority from closing a dam on the Little Tennessee River which would flood and seriously alter Critical Habitat of a fish known as the Snail darter. This followed a decision by the U. S. District Court for Eastern Tennessee to allow construction of the Tellico Dam to proceed despite its conclusion that impoundment of the river would jeopardize the continued existence of this fish. This is a particularly significant decision in view of the fact that the project had begun six years before the Snail darter was discovered, and more than \$100 million had been invested in construction costs. The decision further gave the Secretary of the Interior "a judicial imprimatur" so as to "expedite the adjudication of future cases as well as assist the Secretary in achieving a uniform Federal conservation posture with minimal reliance upon the courts." The extent of project completion was deemed "irrelevant in calculating the social and scientific costs attributable to the disappearance of a unique form of life." The decision went on to note that it is the Secretary and not the courts who establishes the list and determines Critical Habitat, thus even a successful transplant elsewhere would have no bearing unless the new habitat were included in the Secretary's designation. The question of a Congressional exemption for this project has recently been taken up by the Senate Committee on Public Works.

The provision requiring federal agencies to consider the effects of their own programs on endangered species is apparently being taken seriously. The nation's major water development projects agency, the U. S. Army Corps of Engineers, no stranger to environmental litigation, has recently published revised guidelines for its Civil Works Program (*Federal Register* 41:47676-47678). These emphasize a consideration of environmental values equal to that given to engineering, economic, and social factors. Rekas (1976) provides some discussion of the Corps' involvement with endangered species, and outlines the major elements of a Department of Defense memo issued in June, 1974, concerning an endangered species protection program to be initiated and conducted at all military installations and activities. The Corps recently developed a plan to acquire a section of marsh and swamp lands along the Northeast Cape Fear River near Wilmington and designate it a Critical Ecological Zone. Some agencies,

like the Forest Service of the Department of Agriculture and the National Park Service of the Department of Interior, are going well beyond the letter of PL 93-205 in several of their programs. When we consider that there are over a million acres of national forests, 309,000 acres of national parks and parkways, over 41,000 acres of national seashores, many thousands of acres of wildlife refuges, and five major military bases in North Carolina (Nicholls and Stillwell 1975, mainly), and that probably every state agency responsible for large holdings of public land receives some government assistance, the federal commitment here becomes quite important for our interests in these areas.

State, Regional, and Other Involvement

Quite a number of states have endangered species protection statutes, but a law proposed for North Carolina (HB 258) was tabled in the House Wildlife Committee of the 1975 General Assembly. The Wildlife Resources Commission has considerable statutory authority over non-game species in the state, and the Marine Fisheries Commission has the same for marine species. Both agencies have recently joined to propose the designation by regulation of most of the North Carolina animals in the federal lists as endangered species in the state under the authority of Sections 102, 132, 134, 182, and 292 of Chapter 113, General Statutes.

In North Carolina there are also several state laws that directly or indirectly affect the preservation of endangered and threatened species. The Scenic Rivers Act of 1971 has provisions for the protection of riverine habitats. The Environmental Policy Act of 1971, modeled after the 1969 federal bill, requires "agencies of the State to consider and report upon environmental aspects and consequences of their actions involving the expenditures of public monies," and authorizes the governing bodies of local units "to require any special-purpose unit of government and private developer of a major development project to submit detailed statements . . . of the impact of such projects." This Act, which appears headed for demise in September, 1977, has apparently not been administered or widely enforced (Roe 1975).

The Land Policy Act of 1974 proposed a Land Classification System as an implement for local land-use planning, and requires a Land Policy Council to develop recommendations. One major land class is "Conservation," with a number of characteristics that would allow for relatively undisturbed habitats if applied. Council proposals, including those for "Fragile Lands" such as rare species habitats and natural and scenic rivers, can be found in Danby (1976). Scott (1976) presents a simplified description of land classification as a process different from typical regulatory planning devices, like the zoning ordinance.

The Coastal Area Management Act of 1974 established a Coastal Resources Commission to make regulations and policy for land use planning by the 20 coastal counties and their subdivisions. The Commission can designate coastal "areas of environmental concern," in which permit systems would govern development. The general categories include Fragile Natural Resource Areas, and designation of such areas (Complex Natural Areas, Areas that Sustain Remnant Species, Unique Geologic Formations) requires local government approval and presentation at public hearings. The Commission plans to name its final list of these areas in June, 1977. This Act also established a Coastal Resources Advisory Council to be made up of representatives of local governmental units, regional planning agencies,

General Introduction -- State and Other Involvement

and some state departments. The constitutionality of this Act has recently been challenged by Cartaret County officials. Problems in coastal area management are discussed in a number of publications, including Bode and Farthing (1974).

A major effort to conserve important habitats and their species is the Natural Areas System program of the Division of State Parks and Recreation, Department of Natural and Economic Resources. This is designed to preserve and protect natural areas of scientific, aesthetic, or geologic value, and to interpret the natural features and processes of those areas where this can be done without disruption of their values. Natural areas are designed to be subject to State Park regulations as authorized and directed by Section 35 of Chapter 113, General Statutes. This state endeavor is advised by a group of scientists organized as the Natural Areas Advisory Council. A thorough discussion of the Natural Areas concept and programs is in Nature Conservancy (1975).

In July, 1976, the Department of Natural and Economic Resources contracted with The Nature Conservancy, a national non-profit organization, for development of a North Carolina Natural Heritage Program. Financial support was provided by the Mary Reynolds Babcock and Z. Smith Reynolds Foundations, with matching funds from the federal Bureau of Outdoor Recreation. This program is designed to develop a central data system for inventorying locations of endangered and threatened species, representative occurrences of communities and ecosystems, unique geologic and aquatic features, and to identify outstanding natural areas. These data are to assist in protective planning and providing public education services, and the work is complementary to existing programs of State Parks, the Wildlife Resources Commission, the State Museum of Natural History, and others.

The Wildlife Resources Commission recently instituted a Carolina Conservationist Program to benefit non-game wildlife. Funds are to be generated by the sale of memberships.

The interests of endangered and threatened species are also being furthered by research and education in various agencies, and by universities, professional societies, conservation groups, and other citizens organizations. Natural history museums, arboreta, and botanical gardens have historically been concerned with research and education on the distribution, taxonomy, and ecology of plants and animals. Their research staffs are specialists in identifying the broad spectrum of organisms occurring throughout a state or region, or within a particular group, in studying their relationships and needs, and, more recently, in scientific studies of various aspects of animal behavior. The systematics collections and extensive data files made and maintained by these institutions are an invaluable resource, completely irreplaceable in space and time. They are a summary of our knowledge of state and regional natural history. Such holdings, of course, contain a wealth of information on species now considered endangered and threatened, and their study and analysis is vitally important to any program aimed at determining the status of species, subspecies, and other discrete genetic groupings. Even the very simplest devices needed in land-use planning, evaluation of natural areas, and intelligent resource management, such as species lists, distribution maps, statements of relative abundance, and habitat requirements, cannot be provided without recourse to these sources. These institutions, therefore, are in the vanguard of agencies gathering, interpreting, and disseminating objective information on fauna and flora, including species of concern.

The North Carolina State Museum of Natural History has been involved in a continual inventory of the state's fauna and other resources since the early part of this century. We have, however, a considerable distance to go before even a basic catalogue of our animals is complete. Some groups of organisms are well known, but others are essentially unknown. Similarly, the fauna of some areas of the state is less well known than that of other areas. We are now faced with the task of providing information to document declines and extirpations, and identify probable causes, while the data base is very incomplete. A separately funded, interagency Natural History Survey of North Carolina is badly needed.

The State Museum also functions as "home base" and sponsor for the scientific Committee on Endangered and Threatened Biota of North Carolina, whose work did not end, but essentially just began, with the symposium at Meredith College. The Museum has developed an Endangered and Threatened Species Mini-course, which was first offered in the fall of 1976 and was quite successful. This is being extended and modified and will be offered again in the near future. Slide shows and other public education materials on endangered and threatened species are being prepared in the Museum's Education Division, and a major exhibit on these plants and animals is being planned by the Exhibits Division. Members of the Museum's research staff have been actively engaged in studies of specific endangered and threatened animals, like the Bald eagle, Red-cockaded woodpecker, Gray and Indiana bats, Manatee, and Panther, for a number of years, and these research programs are intensifying. Some of these studies are cooperative efforts partially supported by the Forest Service (USDA) and the Fish and Wildlife Service (USDI).

The Highlands Biological Station has been supporting ecological research on endangered animal and plant species of the southern Appalachians. This on-going program will add important information on the ecological life histories and habitat requirements of these endemics or long-range disjuncts.

Many state and regional symposia have been held, like the Meredith College meeting, similar meetings in Alabama, Georgia, South Carolina, Florida, and Maryland, and the Symposium on Endangered and Threatened Vertebrates of the Southeast in Tallahassee, Florida. A number of publications have resulted from these meetings. The Association of Southeastern Biologists and the Ecological Society of America co-sponsored an endangered species symposium at the 1976 ASB meetings in New Orleans (Styron 1976). A number of agencies have instituted computer programs and data files to gather, store, and analyze information on endangered and threatened species. One example is the Regional Assessment and Evaluation Program of the Oak Ridge National Laboratory, Tennessee. A long-range goal of this program is to use its data in predicting the effects of habitat alteration by using multivariate analysis to correlate habitat structure with species abundance and occurrence (Kitchings et al. 1976).

Ultimate Questions and Answers

The questions being asked about the values of endangered and threatened species, weighed in the balance of competition with society's other needs, are complex questions to which there are no simple answers, as much as some people on both sides of the fence would like to think there are. It is easy, for example, to invoke loss of jobs as the only alternative

to activities destructive of other species and their habitats, but difficult to find compromise solutions in the best interests of the environments of this and future generations. It is easy to complain about the horrors of clear cutting a forest, but not so easy to answer the question of where or how better to get timber products expeditiously and inexpensively for all the requirements of a growing population. It is easy to experience and express justifiable outrage at the wastes and excesses of contemporary society, but difficult to provide viable substitute systems for providing a livelihood, economic well being, and food for our people. As ecologists have been saying for at least several decades, one thing we must do before such dilemmas can be resolved is make sure we have distinguished *needs* from profligate *uses*. We seem now to be experiencing the beginnings of a national commitment in this direction.

The habitat loss and modification and other activities which have placed the existence of some 1,000 species of animals, and perhaps 200,000 species of vascular plants, in jeopardy throughout the world stems from growth and development based almost entirely on economic considerations alone. This inevitably leads, as we have seen only too clearly, to ecological damage, no matter how valid the reasons or what political system is involved. Some strategy for use of our lands, waters, and native plants and animals which is economically acceptable and politically feasible, yet will conserve our wealth of species while also conserving our freedoms and a reasonable prosperity, must be found. Responsible planning, with respect for natural communities and ecosystems and all that they mean for the human species, is imperative.

As Jim Williams pointed out in his Keynote Address, the extermination and endangerment of species has not been a deliberate, concerted activity, but is attributable to a lack of ecological knowledge and insights, a general ignorance of what was happening. Today, however, as we become better educated about the values and necessities of properly functioning ecosystems and the finite capacities of what has been rightly called "Spaceship Earth," a broader emphasis on maintaining natural diversity is emerging. If we now fail to address the problems as we perceive them, we can legitimately be accused of dereliction in our stewardship of this land and all that it holds.

About This Volume

Objectives

The aim of the Symposium on Endangered and Threatened Biota of North Carolina was to produce a reasoned document, based on biological concerns, which would identify and provide information on those North Carolina plants, animals, and habitats in need of special consideration. This book is the result, although it is not a conference proceedings in the usual sense. Like the long, rambling Introduction, nearly all chapters were specifically written for this publication.

As will become immediately obvious from even a cursory perusal of the volume, no pretense is made that it provides the definitive last word on the status of our plants and animals. It is a summary statement based on

the most accurate and current information available to quite a large number of knowledgeable specialists at the time of the Symposium, with supplementary comments added in the interim. As such it will provide guidelines needed to make informed decisions in behalf of our biotic heritage. The book is written and organized as a guide for the educated citizen and planner, but is rather schizoid in that much of the information has never been published and will be of considerable interest to academic biologists. Each Group Committee functioned independently within the broad guidelines established by the Steering Committee, and the resulting lists of species and their categories vary from conservative to fairly liberal. In part, this is a function of our greater knowledge of some groups, but may also be reflective of differences in philosophy based on the nature of the biota involved. For example, the Committee on Birds felt that trying to determine status for transient species would be a meaningless exercise, thus concentrated its efforts on breeding birds.

Although the species lists carry no legal weight except for those species protected under existing laws, we hope that this reference will be consulted in early planning to avoid additional stress to sensitive habitats and species. *It must be emphasized, however, that superficial use should not be made of the lists and accounts.* While we are eager that sensitive species be given every consideration in planning, recommendations for action or inaction must not be made without recourse to the most complete sources of information possible.

A constant theme encountered herein is the great need for basic research on our biota. In some cases (notably, but by no means exclusively, in the non-marine mollusks and arthropods) confusion still reigns at the level of alpha taxonomy. Many of the species have not yet been described and named in the scientific literature. And, of course, for the great majority there is a deficiency of ecological information.

Although the November 1975 Symposium did not specifically address management and enforcement considerations, deferring these to a planned future symposium, comments on these topics can be found in some of the species accounts.

Production

Because it was our intent to go to press as soon after the Symposium as possible, and to exercise sufficient control over production to allow the insertion of current information as it came to our attention, we decided to use the off-set, camera-ready method of printing. Some other method would have doubtless been more attractive, but, although circumstances beyond our control caused unfortunate delays in publication, we hope that the way we have gone about it at least has the advantage of a certain timeliness. It was also less expensive this way, which has allowed the Museum to devote more of its limited funds to other aspects of endangered and threatened species education.

Despite the fact that different sections were typed at different times, over a prolonged period, we attempted to maintain as much uniformity and consistency throughout the book as possible. This goal was not always met, but no time has been devoted to the picayune as long as meanings were clear. We attempted, for example, to make hyphenated word breaks at the ends of lines conform to pronunciation, but have not bothered to check all against our Webster's, or correct those few that we know do not. Similarly, literature citations are as consistent as

possible, but we have not paid undue homage to conformity as long as the references were findable as cited.

In many cases the discussions are necessarily sketchy, but, although the list is far from exhaustive, sufficient references are provided to get the interested reader into the pertinent literature. The great majority should be, or at least lead to, the major sources of information.

Organization and Style

The general organization of the volume, and the format and style of the chapters, accounts, and subdivisions, were decided by the Proceedings Committee. Each major group of organisms is discussed in a separate chapter, according to Group Committee assignments. Several brief discussions of species of concern not discussed at the Symposium are included as a "chapter" on *Other Invertebrates*. This decision was made by the Steering Committee prior to the Symposium.

A specific chapter *Introduction*, usually written by the Group Committee Chairman, is followed by a number of references. In addition to literature cited in the Introduction itself, they include general references cited frequently in the Species Accounts.

Each chapter Introduction is followed by a *Species List*, which also provides the vernacular name (where it exists or could be coined for this book), the status of each species, and the page number where the Account can be found or begins. The animal lists are first arranged phylogenetically by higher taxa, in almost all cases to family, then alphabetically by genus and species within these taxa. The list is followed by *Species Accounts*, and complete write-ups are generally provided only for those species considered *Endangered* or *Threatened*. Several committees extended this full coverage to species of *Special Concern*, while others provided only an annotated list of such species. Those forms for which the available data were too sparse for a more accurate assessment but for which concerns were nonetheless felt, usually rare species, are listed as *Undetermined*. In most cases they receive some comment. The Accounts are first arranged by status, in decreasing order of concern (i.e., *Endangered* first, *Threatened* next). Within each status category they are arranged phylogenetically to family, then alphabetically by genus and species. Explanation of the different arrangement of the plant Accounts is provided in the Introduction to the *Vascular Plants* chapter.

Each Account is headed by the names of higher categories, and the common name of the family if one exists. Then the scientific name of the species, and the authority or authorities, are given at the left of the page, with vernacular names to the right. Recent synonyms of scientific names are provided in those cases where confusion may have resulted from their omission. No more than two common names are given for any species, although others may be provided under Remarks. The names of fishes are from *A List of Common and Scientific Names of Fishes from the United States and Canada*, 3rd Edition (1970), Special Publication No. 6 of the American Fisheries Society, by Reeve M. Bailey and Committee. The names of amphibians and reptiles are those standardized by a committee of the American Society of Ichthyologists and Herpetologists, as used in Roger Conant's *A Field Guide to the Amphibians and Reptiles of Eastern and Central North America* (1975), Houghton-Mifflin Company, Boston. The names of birds follow the American Ornithologists' Union's *Check-list of North American Birds*, 5th Edition (1957), updated from supplements. Mammal

names are those in general usage today, although no official standardization of these names is available. Most, but not all, of those species for which standard common names do not exist have had names coined for this volume, and their origins are largely self explanatory, although a few are explained in copious detail. These are not necessarily to be considered the standard common names of the species involved.

Names are followed by a brief *Description*, intended to provide the reader with at least some "sense" of the organism, and in some cases to allow identification without recourse to further references. Illustrations are provided for some plants and invertebrates. In all cases where such materials were known to the authors or editors, specific literature sources of illustrations, keys, and other identification aids are given. Most descriptions in the *Birds* chapter are omitted, since standard field guides are numerous, but references are provided even here for all species.

The Description is followed by a *telegraphic* presentation of *Distribution*, which gives both general range and information for North Carolina. A section on *Habitat and Mode of Life* comes next, containing not only general habitat descriptions, but information on food, behavior, and, in some cases, limited reproductive data. Where sufficient data on reproduction were available, a separate subdivision on *Reproduction* is provided. A section on *Status* first states the category in which the species has been placed, then discusses the rationale behind this assignment. It may also provide a forum for questionable occurrences, a discussion of protective measures now in effect, numbers in captivity, suggestions for protection and research, and comments on the values of the species and its status elsewhere, particularly in other parts of the southeast.

A section for *Remarks*, often omitted, may include additional vernacular names and their derivations, further comments on values, and, in general, any pertinent information not covered elsewhere. *References* for each account follow. Oft-cited references are just listed by author and date, and the reader is instructed to "see list following introduction" for these particular citations. While this may result in some minor inconvenience, it prevented mass duplication of certain references and enabled us to save a number of pages. This was more of a problem for some chapters than others.

Reference is made throughout the book to the "federal list," which is the list of Endangered and Threatened animals published and updated in the *Federal Register*. The most recent of these is found in *FR* 41:47181-47198, 27 October 1976. Reference is also made in many accounts to the "IUCN list" or the "IUCN Red Book," which is the *Red Data Book* of the Survival Service Commission, International Union for Conservation of Nature and Natural Resources, Morges, Switzerland.

The last major chapter in the volume discusses *Cluster Areas*, which are sites or systems of varying sizes where groups of species of concern are "clustered." By taking steps to prevent habitat destruction and modification in such areas, a number of species can be simultaneously conserved.

Information on how to cite this volume and its sections is provided as the last item in the *Epilogue*.

The editors of this book would greatly appreciate having needed corrections and additions brought to their attention, and would be most receptive to comments on its contents.

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The quote from *The Lives of a Cell* by Lewis Thomas, © Viking Press Inc., which appears on page vi, is used by kind permission of The Viking Press Inc., New York, New York.

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Symposium Keynote Address

Endangered Species: Yesterday, Today, and Tomorrow?

by

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Extinctions have been a biological phenomenon since the dawn of life on earth, and thus so have endangered species. This basic biological *fact* became a biological *problem* with the appearance of Man and his ability to exploit living resources and alter his environment more rapidly and dramatically than all of the natural processes put together. Looking around us today, we find more and more species becoming endangered or threatened with extinction. The real problem, however, is not one of numbers of endangered species or extinctions -- it's the rate at which they are occurring, which is growing literally by leaps and bounds.

Some of the first evidence of Man-induced extinctions may be found in the record of disappearance of large mammals at the end of the Pleistocene. While some may debate this point there is increasing evidence that, in North America, the arrival of Man across the Bering land bridge about 12,000 years ago produced an unprecedented wave of large mammal extinctions -- 33 genera, including mastodons, mammoths, camels, horses, and ground sloths, disappeared during this period. In a recent article, Mosimann and Martin (1975) present a computer simulation model which hypothesizes that "by prehistoric blitzkrieg, 300,000 hunters in North America could wipe out 100 million large animals in 300 years."

When we look for early attitudes towards endangered species in the United States, we see only a blank ledger. There were no attitudes, for our recent ancestors did not realize that the problem existed. Their outlook was simple: resources were put on earth for Man to use, to take and make the most of with little consideration for conservation and the need to protect the renewable aspects of the resources. This attitude was grounded in the twin philosophies of "always more over the next hill" and "make a buck today and let tomorrow take care of itself." Gradually, however, attitudes began to change. In 1898, speaking before the National Fishery Congress in Tampa, Florida, Dr. Bushrod James said:

"That we have not discovered the use of every living thing does not prove that aught was given life in vain. Therefore let the fish commission raise its voice against the cruel destruction of any living thing over which its prerogatives may reach, thus securing safety not only for the wards of their hatcheries but for the food supply for them and other creatures."

People were beginning to realize that, for large parts of our natural heritage, "next hills" were becoming scarce, and "tomorrows" even scarcer. This growing environmental awareness and concern was reflected in the setting aside of the first National Parks, Wildlife Refuges, and

Keynote Address

the 1899 Refuge Act. One of the first creatures to benefit from this new attitude was the buffalo or American bison. After reaching a low point of 300 to 500 animals, it was finally rescued. In fact, it is doing so well today that it has commercial possibilities, buffalo burgers and all. The American bison was one of the first success stories in endangered species rescue efforts. Unfortunately for many other critters — Great auks, Passenger pigeons, and probably countless fishes and lower animals, and plants — the new awareness came too late. For these species the questions constantly arise: Who is to blame? What did we do that was wrong?

One of the first answers which some people suggest is overutilization — overfishing, overhunting, or some other expression of excessive direct human predation. In most cases, however, this easy answer does not hold up under close analysis. True enough, a few species were reduced in numbers due to market hunting, commercial hide and fur trapping, and simple senseless slaughter. But the most serious threats, today and in the past, are the environmental changes caused by human activities. These changes may be chemical, physical, or biological. One of the problems here is that it is often difficult to identify just *exactly* what is threatening some critter. A subtle change in one factor may set off a chain reaction in others. This is an inherent characteristic of the ecosystems in which every living thing survives (or dies) — a change in one component alters many others.

One obvious example which is presently affecting a lot of our aquatic animals and plants is that of impoundments on our major rivers. The alteration of current from stopping a river behind a dam; changing flow patterns and temperature of the release downstream; silting or sedimentation of materials in the reservoir — all contribute to the decline of organisms adapted to stream life, and consequently threaten their existence. Another is stream channelization, something which is certainly not new to us in the Southeast. Here is a situation where a stream is typically converted from a fertile, meandering, diverse ecosystem to a plain and simple ditch. The changes that accompany this conversion are numerous, and almost every one can be named as a factor that threatens populations of a species. Because these problems are localized, each individual case may seem to be insignificant. Nevertheless, they begin to catch up with you when you consider these activities on a national basis.

Some of the less obvious problems include such things as pesticides and other toxic chemicals. Once they are applied to a particular crop or area you no longer see or smell them, but their effects are long lasting and reach into the future. The disturbance of symbiotic relations of things like mussels and their host fishes is a problem that we are finding often endangers freshwater clams. An especially subtle and difficult problem is hybridization of habitats, which in turn permits hybridization of species. What was formerly two distinct gene pools become so mixed that they are no longer recognizable. The introduction of exotics is a problem, especially in aquatic systems. Courtenay and Robins (1975) state that more than 100 million fishes were imported into the United States in 1972 alone. The majority of these pose no danger to native fishes, but it only takes a few escaped or released into native waters to start an ecological disaster. In Florida, 24 species and 5 hybrid exotic fishes have become established already. In other areas, game fishes like

sunfish, catfish, and trout have been put into springs and streams housing a population of an endangered species. These aquatic ecosystems frequently have not had the pressure of a major predator, and this alteration has contributed to the decline of several species of fish in the west. Eutrophication, the addition of nutrients to aquatic systems, is another example of something that is not immediately obvious or effective, but over a period of time can do tremendous damage.

Getting away from the problem of habitat alteration, we find that commercial activity has occasionally contributed to the decline of a species. We have only to look at fur and hide bearers like the spotted cats, some of the turtles, and alligators and crocodiles. The American alligator, on the other hand, is turning out to be another success story. This is the species that has been a focal point, along with the Whooping crane and Devil's Hole pupfish, of concern for endangered species in this country in recent years. With protection, the Alligator has made a roaring comeback, to the point now that some people in Florida and Louisiana consider it a pest. We have opened up a harvest for 'gators in three parishes in Louisiana. Some preservationists may object to the harvest, but the important thing is to look at what kind of contribution this is really making to the overall effort to save species. A few Alligators are taken, but the species is not harmed by a carefully regulated harvest. More importantly, when a harvestable population of Alligators is present in a wetland area, chances are the area will not be drained to turn it into a monoculture soy bean or cane field. This in turn contributes to the survival of other species which may be endangered or threatened.

Now let's turn to some of the effects of these factors on our animal and plant populations. I reiterate that extinction is a natural process, but what has happened in recent years has been acceleration in its rate. The estimates range from a four- to twelve-fold increase in extinction of warm-blooded vertebrates induced by Man and his activities. Certain areas in the United States have been particularly hard hit by this mushrooming rate of extinction. One of the worst cases is the state of Hawaii, where nearly half the native flora may be in danger. Of the 3,000 or so plants reviewed for listing as *Endangered* or *Threatened* by the U. S. Fish and Wildlife Service, approximately a thousand taxa were restricted to one or more of the Hawaiian Islands. Twenty-four species or subspecies of birds are already extinct there, and the only native land mammal, the Hawaiian hoary Bat, is on the *Endangered* list. Another sensitive area in the United States is the southwestern desert. The primary problem there is scarcity of water, and any organism that has its existence tied directly to this resource is in great danger. The water is being depleted very rapidly, and the problem is difficult to handle since much of it is on private property. Early in 1976 the Supreme Court will hear a water rights case which could set an important precedent for our efforts to save southwestern aquatic species, that of the Devil's Hole pupfish. While we generally think of the Supreme Court as deciding important social issues like capital punishment, in this case the fate of a whole species — survival or extinction — hangs on its decision.

Among the species that disappeared during the early history of the United States were the Carolina parakeet, Passenger pigeon, and Harelip sucker, each for a different reason. The Carolina parakeet was considered a pest by some people. The reason for the decline of the Harelip sucker was likely habitat alteration. The problem with the Passenger

Keynote Address

pigeon, which was used as food for humans and livestock, was a combination of overutilization and alteration of habitat. Comparing these extinctions of the past with what's happening today, a significant difference can be seen. In the past extinctions were unpredictable and usually unnoticed. Nobody knew they were happening, or if they did they were not conscious to the point of recording it in writing. Responsibility for these early extinctions is very difficult to fix. A few people killed certain forms for food, some cut down forests and silted streams, but it is hard to tie down who was responsible for the demise of, say, the Carolina parakeet. Today the situation is quite different. We have reached the point where we can often determine that a particular action is going to result in the demise of a specific species. We can look at the clearing of forest lands in Hawaii and say that it could result in extinction of certain forest plants and birds. We can look at construction of a dam, or channelization of a stream, and say that it will threaten a particular aquatic species.

Two groups with which I am most familiar are mollusks and fishes. There are at least 14 mollusks, mostly freshwater mussels of the Cumberland, Tennessee, and Ohio River systems, known to be extinct. That in itself is a sad record, but even sadder is the fact that there are another 20 species that probably will become extinct in the next decade if things are not turned around. For some of these it may already be too late. It is not a matter of asking, "What is the problem?" We know what the problems are and why and where they are occurring. The real difficulty is reversing these situations. In the past Century we have lost at least 15 species and 2 subspecies of fishes. They were not restricted to any one area of the country. Running through the list briefly we can point out the problems and where they occurred. In Oregon the Miller Lake lamprey became extinct when the lake was cleaned out in 1950 to get rid of "trash fish" to stock it with game species. This extinction was not intentional; they just didn't know what was there. Many extinctions have occurred this way -- no one knew what was happening, or what they were doing to a particular species. In the Southeast the Smoky madtom, known from a tributary of the Little Tennessee River in east Tennessee, is apparently extinct. This species was turned up only one time, in a fish control operation in 1957. The discovery of the fish unfortunately coincided with its demise. In Utah the June sucker and Utah Lake sculpin both inhabited Lake Utah. During the 1930's, water diversion projects reduced the level of the lake and eliminated these species. In Florida there is an unnamed shiner that is apparently extinct, again a species that was taken only once, in the Blackwater River. The Whiteline topminnow, known only from Big Spring in Huntsville, Alabama, was last taken around the turn of the Century. In this case habitat alteration was probably the primary factor in loss of the species. The spring was impounded by a small dam, and the banks were dug out and lined with concrete. This made a nice pool in a park, but it did not do much for the Whiteline topminnow, which is apparently extinct. Still another example of a species which declined as a result of habitat alteration was the Thicktail chub in the Sacramento and San Joaquin Rivers of California.

One of the jolts which awakened environmental awareness in the late 1960's came when Lake Erie was pronounced dead. Two fishes, the Deepwater cisco and Blackfin cisco, disappeared from the lake during that period. Before then they were still showing up in the commercial harvest.

Their demise was probably due to pollution, overharvesting, the Sea lamprey, and possibly hybridization. Here we have another example of extinctions for which we cannot precisely identify the factor responsible. In Nevada there were a couple of small minnows that went by the wayside when carp and trout were introduced into the pond where they occurred. The presence of an exotic predator resulted in their downfall. The "Passenger pigeon" of the fish world is the Harelip sucker, the first fish known to become extinct in the United States. It was last collected around 1893, and probably disappeared as a result of habitat alteration. From these examples you can see how we have lost a number of species over the years. The operative factors in their loss remain: we still have habitat alterations and introductions, and all the other factors that have caused extinctions and extirpations. The big difference is that in many cases today we can identify those activities likely to bring about the demise of a species, and attempt to solve the problems.

At this point perhaps we should stop and ask, "Why bother to save endangered species? So what about things like the Snail darter? There are others that look just like it in the next creek." These are legitimate questions which bother many people. First of all, it's important to distinguish between the furry, soft-eyed critters with which most people find it easy to identify, and the scaly or slimy critters which seldom make the front covers of popular magazines. It would be much easier to sell people on the idea of saving a darter if it was warm and cuddly. Nevertheless, I think there are two outstanding arguments for the importance of *every* species of animal and plant, regardless of how cute and cuddly, or slimy and repulsive, it may be.

First of all, in terms of direct benefit to humans, there is no way to predict in advance those species which may hold secrets useful in solving many types of problems. Let's look at the Red jungle fowl, a rare and secretive bird of Asia, as an example. If it were in trouble and we were to start an expensive campaign to save it, many people might accuse us of starting another boondoggle. But it just so happens that this supposedly insignificant fowl is the direct ancestor of our domestic chicken, the foundation of a multi-billion dollar poultry industry, and a protein source for people all over the world. On the medical front, one of the most important hopes for future progress is the biochemical diversity of different species of plants and animals. The Snow leopard, it turns out, had a biochemical feature which enabled researchers to develop the distemper vaccine your veterinarian administers to the family cat. Some of our endangered species may have other unrecognized biochemical adaptations which could prove to be tremendously valuable in the future. Can we really afford to let them go? Suppose a half-Century ago citrus growers had gotten together with the chemical industry and mounted an all-out campaign to eradicate the blue green mold that rotted their oranges and grapefruits. Chances are it would have been extinct before anyone realized it could be the source of one of the great wonder drugs, penicillin. It would be wrong to argue that every endangered species has locked up inside its tissues a new food source or a cure for cancer. It is right to say, however, that every time we eliminate a species we eliminate the possibility of identifying its unique features, and what value they might be to humanity.

Keynote Address

The second argument for saving endangered species is rooted in their importance as members of whole communities of animals and plants. No species lives in a vacuum — it is a member of a particular type of ecosystem and plays some role in the continued healthy operation of that system. Blackflies and mosquitoes may seem to be creatures with absolutely no redeeming virtues when they're eating you up on a fishing trip, but the trout and other game fishes that you're after may well depend on their larvae as a principal food source. A recent event in South America is one more illustration of the disastrous consequences which excessive tampering with natural ecosystems can bring. To increase the production of fish in inland lakes, one country began a program of wholesale elimination of the Caiman, South America's equivalent of the Alligator. As the program went on, however, fish production didn't increase, it went steadily down! It turned out that the main food of large Caimans was not fish, but terrestrial animals coming to the water to drink. The Caimans were actually bringing a new nutrient supply into the lakes, and this was an important basis for the whole food chain in the ecosystem. When the Caimans were eliminated, productivity of the lakes dropped. This is but one small example of the importance of saving individual species not just for their own sakes, but for the health of an entire ecosystem. When we lose a species we lose not only the biochemical potential within its genes, but its contribution to diversity and stability of the natural environment as well.

I have painted a rather dim picture so far, and maybe at this point we should turn and examine the brighter side of the outlook for endangered species. First of all, we have the Endangered Species Act of 1973, a historic and very tough piece of legislation. It not only provides for rigid protection of those species which are considered to be *Endangered*, but also adds a new category, *Threatened*, to acknowledge the status of species which are not presently endangered but which could become so unless steps are taken to turn things around. One of the most important goals of the Act is to "provide a means whereby the ecosystems upon which Endangered species and Threatened species depend may be conserved." The Act thus gives formal recognition to the "ecosystem approach" which I just mentioned. Another encouraging sign is meetings like the one we're all participating in today. It is very reassuring to see a group of biologists and interested laymen get together for a two- or three-day conference to concentrate totally on potentially endangered species, to ask "What is their condition and what can we do about it?" We are really making progress. There are many things you can do. I've already mentioned the Federal Endangered Species Act, a very good piece of legislation. One of its main features is the encouragement of states to enact their own Endangered Species legislation, by providing grants-in-aid for those with acceptable programs. Many states do not have appropriate legislation to qualify, so here's one area where individual effort by concerned biologists and others is needed. I encourage you in North Carolina to push for a state bill in the next session of the legislature.

Another bright spot on the endangered species scene is the international agreements to protect such species on a worldwide basis. We are now able to regulate trade in foreign endangered species, which affords protection by eliminating the U. S. market. While this does not protect the habitat of an animal or plant, it does help maintain populations. Two

other groups that are involved in international efforts are the International Union for the Conservation of Nature (IUCN), and the World Wildlife Fund, both of which support research projects, acquire land, and work in other ways. The IUCN also publishes a series of Red Books on endangered species, which are invaluable sources of information.

Here in the United States, groups like the National Wildlife Federation, Audubon Society, and Sierra Club, are doing a terrific job of bringing problems to the attention of the public and suggesting ways they might help solve some of them. The Nature Conservancy is doing excellent work in acquiring land, which may be the only hope for some of our endangered species. Also concerned for the welfare of these organisms are the American Rivers Conservation Council, Environmental Policy Center, National Parks and Conservation Association, Friends of the Earth, and Natural Resources Defense Council. All are private conservation groups that depend on support from individuals. If you don't already belong to one, pick one out and get involved in its programs.

Professional societies like the American Fishery Society and the American Malacological Union are also turning considerable attention to particular kinds of endangered and threatened species. Others, like the Association of Southeastern Biologists, contribute by having symposia and concentrating on such problems as we are currently discussing. Another group that plays an important role today, and will play an even bigger role in coming years, is the state game and fish commissions or natural resources departments. Their efforts to identify problems, set aside land, and intelligently manage resident animals and plants, will make a significant contribution to saving endangered forms.

All in all it's been a steady decline for many species. Today, however, groups like this with members like you are going to reverse the unfortunate trend, and help push our declining wildlife and species diversity back up to a secure position.

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Vascular Plants

Introduction
by
James W. Hardin

History

North Carolina has a rich and varied flora which has attracted and held the interest of professional and amateur botanists from colonial days to the present. Early botanical explorers like John and William Bartram, André and F. A. Michaux, John Fraser, and Thomas Nuttall spread the word regarding the magnificent wilderness and botanical paradise that existed from the coast to the mountain peaks.

The earliest account of the plants was by John Brickell (1737), but one of the first descriptive floristic manuals to appear in Colonial America, and the first for the state, was Walter's "Flora Caroliniana" (1788). This manual, written in Latin, included about 1,020 species of vascular plants. Reverend Moses A. Curtis, living for periods of time in Wilmington, Raleigh, Hillsborough, and the mountains, prepared the most comprehensive and scholarly "Catalogue" (1867) of the state flora that had been published to that time. It included 1,921 species of vascular plants, plus 2,928 species of algae, fungi, lichens, mosses, and liverworts. No such catalogue including the total flora has been prepared since. This was partly superseded by the work of Hyams (1899), which listed 2,685 vascular plants.

During the years since Hyams' Flora our knowledge of the plants has been immeasurably increased by such botanists as W. W. Ashe, T. G. Harbison, J. K. Small, W. C. Coker, H. R. Totten, H. L. Blomquist, B. W. Wells, W. B. Fox, H. J. Oosting, R. K. Godfrey, H. E. Ahles, C. R. Bell, A. E. Radford, E. O. Beal, and R. L. Wilbur. The most complete floristic manual of the vascular flora was written by Radford, Ahles, and Bell (1968). Descriptions, keys, habitats, and distributions are given for 3,360 species, 12 subspecies, and 162 varieties in both North and South Carolina. Since the publication of this Manual additional species have been found. Although no up-to-date total has been determined for North Carolina alone, a fairly close, working figure is 3,400 taxa of vascular plants.

Specimens are preserved in several herbaria in the universities of the state, plus the United States National Herbarium, the New York Botanical Garden, the Gray Herbarium of Harvard University, and others. The three largest North Carolina herbaria are those at the University of North Carolina, Chapel Hill; Duke University; and North Carolina State University. They have a combined total of over a million specimens which serve to document distributions, precise habitats, and morphological variability. The specimens in these collections are the major permanent record of the state's flora, and represent a state and national resource of tremendous importance and inestimable value.

North Carolina is fortunate to have this long record of interest, plant explorations, collections, and publications which provides a basis for assessing the status of the vascular plant species. Although the fresh-water algae of North Carolina are well known (Whitford and Schumacher 1973), no attempt has yet been made to determine the endangered

species of lower plants (algae, fungi, lichens, mosses, and liverworts). They should eventually be identified, for they undoubtedly will be indicators of unique habitats which should be preserved.

The Future

We hope that this account of the endangered and threatened vascular plants will aid legislators and conservationists in the formulation of new regulations or laws for increased protection of the native North Carolina flora and the habitats in which they exist. It should also alert the general public to the precarious status of numerous plant species and unique environments in the state. Such a report should be useful to individuals and organizations interested in designating "natural areas," and maintaining wild flower sanctuaries or botanical gardens. The information contained here should be valuable in the preparation of "environmental impact statements," and publicity or educational programs regarding the endangered plants of the state. It is also hoped that this report will give the impetus to an ongoing and vigorous research program leading to a greater understanding of the taxonomy, ecology, and reproductive biology of these organisms.

We sincerely trust that the report will not encourage people to dig up the few remaining specimens from their natural environment and transplant them into private gardens, where they rarely survive. Such selfish, private exploitation must not occur. Commercial interests should turn to nursery propagation rather than digging plants from their native habitats.

Status

The committee is recognizing 409 *Rare* species of native vascular plants of North Carolina, which represent 12% of the total vascular flora. Because of their rarity, relatively few of these are known by the public, or amateur and professional botanists. Nevertheless, there is deep concern for the preservation of all of these, and their status in the state should be monitored constantly. Omitted from this list are chance hybrids which may occur rarely between closely related species, and also taxa at the varietal level unless they are considered quite distinct and occupy unique habitats in the state.

A *Rare* plant is difficult to define precisely since the concept of rareness involves two variables: first, the overall distribution; and second, the relative density or frequency of individual plants within that distribution. This difficulty is compounded by the fact that the limits of both variables are entirely subjective. Figure 1 illustrates this relationship. The extreme in rareness, point A, would be a species like the Bladen buttercup, represented by very few individual plants and also restricted to an extremely limited geographical area. The other two extremes are also considered "rare," but this status may not be so obvious until the total picture of both range and density are considered. Point B is represented by a plant such as Lewis' heart leaf, which occurs over a fairly broad range but in very low density. Point C is represented by a plant like Oconee bells, which is locally quite abundant but still rare since its total distribution is very limited. The concept of rareness includes all possible intermediates between these three extremes. The

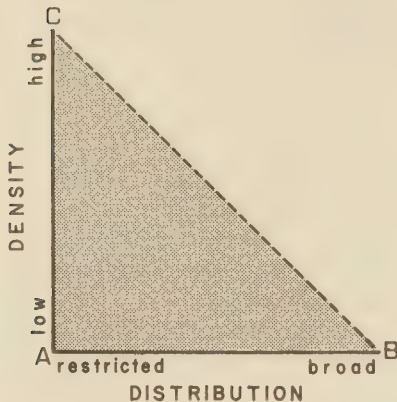


Figure 1. Relative rareness of plants as a function of distribution and density.

element of the total genetic diversity of the species, and this state is the "keeper" of this one important segment of the entire range. Their elimination here may represent a considerable loss in terms of the gene pool, and also a great loss in terms of the natural history of North Carolina. An example is the Palmetto palm which, although common farther south, is a rare and unique element in the forests of Smith Island and the southern coast (Figure 2A). The 318 *Endangered* and *Threatened* peripheral species are listed in Table 3.

The endemics, long-range disjuncts, and those species that are rare throughout are of greatest concern. Conservatively, there are 91 of these, listed in Table 2 and also described individually. We are very fortunate that these represent but 2.7% of the vascular flora of North Carolina, in contrast to the estimated 10% endangered and threatened species for the entire United States. Preservation must start with these 91 species, for they are extremely vulnerable to alteration in their habitats and are either immediately endangered or likely to become endangered if not provided with protection.

A long-range *disjunct* in North Carolina is a rare segment of a species population which is significantly separated, by a few hundred miles or more, from the main area of distribution where it may be quite common. For example, Wright's cliff-brake fern occurs in the North Carolina Piedmont, nearly 1,000 miles east of its normal range in southwestern United States (Figure 2B). The Dwarf polypody fern, which occurs in North America only in Macon County, is a disjunct from the American tropics. Such populations often represent a significant relict of past geological times, and usually mark a unique and interesting habitat within the state which should be preserved.

An *endemic*, for our purposes, is a species which has its native area totally confined to a small area of North Carolina and possibly adjacent parts of neighboring states, existing nowhere else in the world except possibly under cultivation. Examples of North Carolina endemics are

dashed line on the graph represents the subjective limit of the concept of rareness, and any species too common and widely distributed to be included within this limit would not be considered rare.

Plant species are rare in North Carolina for various reasons. They may be at the periphery of their range, or they may be long-range disjuncts or endemics. They are considered as either *Endangered* or *Threatened* by the very fact that they are rare. *Peripheral* species may be fairly common either north, west, or south of North Carolina, but rare at the terminus of their distribution here. We argue that these native, peripheral species represent an integral part of the North Carolina flora and a probably significant



Figure 2. Types of distributions of North Carolina rare plants.

A. Peripheral species (Palmetto palm). B. Disjunct species (Wright's cliff-brake fern). C. North Carolina endemics (Cooley's meadowrue in the southeastern Coastal Plain and Mountain hudsonia in Burke Co.). D. Southeastern Coastal Plain endemic (Venus' fly-trap). E. Piedmont-Coastal Plain endemic (Lewis' heart leaf). F. Southern Appalachian endemic (Spreading avens).

Cooley's meadowrue and Mountain hudsonia, known only from the southeast and Burke County, respectively (Figure 2C). The range of certain other endemics may extend over state lines. Examples would be Venus' fly-trap, which occurs in three counties of South Carolina (Figure 2D); Lewis' heartleaf, which extends into southeastern Virginia (Figure 2E); and the southern Appalachian endemic, Spreading avens, which is also in eastern Tennessee (Figure 2F).

An *extinct* species is one which was endemic and known to exist naturally in North Carolina during earlier times, but is no longer found. An example is Bigleaf Scurfpea, collected only once in 1897 in Polk County. An *extirpated* species is a disjunct or peripheral species which is no longer found in North Carolina but still occurs elsewhere. For example, Sweet gale, which normally ranges from Pennsylvania northward, once occurred as a disjunct in Henderson County. If these apparently extinct or extirpated species are ever found again in North Carolina, they should automatically be considered *Endangered*.

Exploitation, either private or commercial, is a potential threat. Such plants as Ginseng and Goldenseal are collected for the crude drug trade, and extensive digging of the roots can be a definite threat to continued survival. When Chinese ginseng was eliminated long ago from its native area by over-exploitation, the multimillion dollar trade turned to our eastern North American species. It, too, is now threatened, even though widespread. Venus' fly-trap has become a popular novelty and house plant in recent years. Although locally common, it is threatened with over-exploitation by commercial interests, who should turn to greenhouse or nursery grown plants entirely. Rareness is also an unfortunate enticement for many enthusiasts to dig such plants for their private gardens. Certain dealers even advertise "rare" plants. Backyard gardeners will have to show their appreciation of these plants by leaving them in their native habitats, and should transfer their efforts to the preservation of "natural areas" or other means of protection and management. "Management" in such cases may not always mean leaving the habitats alone, for many of these species exist in early successional stages of the vegetation. Periodic cutting or burning may be a necessary management practice for them to persist.

The list of 91 species presented here supersedes the preliminary list published by the North Carolina Department of Natural and Economic Resources in 1973. The NER list was hastily drawn up and completed prior to basic decisions regarding the categories to be included. These 91 are also very different from the 144 species previously placed on a "conservation list" prepared by the North Carolina Garden Clubs and the North Carolina Wild Flower Preservation Society. The plants on their list are, for the most part, the showy or popular species in our flora such as bloodroot, mayapple, flowering dogwood, and mountain laurel. These are all important, and we need to guard against their possible over-exploitation by the "plant diggers," but they are not rare and cannot legitimately be considered of great concern. This present list also differs from the federal one published in the *Federal Register* (40(127), pt. V, 1975), principally by the inclusion of long-range disjuncts. Those species which are extinct, endemic, or endangered or threatened throughout their range appear also on the federal list.

The county distributions of the 91 extinct, endangered, or threatened species are shown on a composite map (Figure 3) and in Table 1, and indicate concentrations in certain areas. These cluster areas reflect unique habitats where endemics or disjuncts persist. Our preservation efforts will have to concentrate on habitats and unique plant communities, for their protection is the obvious means of conserving the individual species.

Explanation of Lists and Species Accounts

Table 2 is an alphabetical list of the 91 species of primary concern. The status of each, and the account reference numbers, are given after the names. Every effort should be made to preserve these species as they exist in North Carolina. We prefer to think of them as constituting a single group of primary concern, with little distinction between *Endangered* and *Threatened* categories. If any order of priority is necessary, it should be: (1) endemics, (2) endangered and threatened throughout, and (3) disjuncts.

Most nomenclature, and the order of the families in the species accounts, follows Radford et al. (1968). Reference to the more complete descriptions in the "Manual" is given at the end of the general description of each species, e.g. (Man. p. 6).

The source of each illustration is given at the end of the description. UNC Press = University of North Carolina Press, and these illustrations are from the "Manual" (Radford et al. 1968), or Coker and Totten (1945). NYBG = New York Botanical Garden, and the figures are from Gleason (1952), or Mackenzie (1940). SIU Press = Southern Illinois University Press, and the source is Mohlenbrock (1967). USDA = United States Department of Agriculture, and the figures are from Hitchcock (1950). We greatly appreciate permission to use these illustrations provided by the institutions and agencies indicated. The sources of illustrations taken from journal articles are cited in the references for each species.

Table 3 lists the native species which are rare, either endangered or threatened in North Carolina, but peripheral in distribution. They appear here in the order in which they occur in the "Manual". Although found in adjacent states, care should be taken that these species do not become extirpated here.

These lists and the information presented in this report will remain open for additions as well as deletions, changes of status, and additional county distributions as our knowledge about each species in North Carolina increases. Anyone having recommendations is urged to contact the Chairman of the Plant Committee. Information will be maintained at the Herbarium, Department of Botany, North Carolina State University, Raleigh, NC 27607.

The preparation and writing of this entire report was a cooperative effort by R. L. Kologiski, J. R. Massey, J. F. Matthews, J. D. Pittillo, A. E. Radford, and J. W. Hardin, *Chairman*.

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Vascular Plants -- County Distributions

Table 1. County distributions of vascular plants of primary concern.
Numbers refer to species accounts. Counties without such
species are omitted.

Alexander 2	Henderson 7, 22, 24, 26, 29, 30, 31,
Alleghany 55	33, 37, 49, 54, 65, 80, 87
Anson 42, 49, 50	Hoke 49, 61, 62, 68, 82, 91
Ashe 18, 19, 20, 25, 54, 55, 58,	Iredell 36
65, 69, 70, 85	Jackson 20, 24, 28, 30, 43, 55, 65,
Avery 10, 18, 20, 25, 30, 32, 51,	70, 87, 88
54, 58, 70, 84, 85, 90	Johnston 9, 28, 49, 91
Beaufort 17, 52, 73	Jones 3, 4, 13, 28, 41, 52, 91
Bladen 4, 13, 17, 38, 44, 47, 49,	Lee 65
52, 68, 82, 91	Lenoir 13, 38, 52
Brunswick 9, 13, 29, 45, 49, 52, 62,	Lincoln 39
64, 66, 73, 76, 86, 89, 91	McDowell 25, 54, 72, 85
Buncombe 7, 16, 18, 23, 25, 28, 30,	Macon 6, 16, 18, 19, 20, 28, 30,
34, 35, 37, 49, 54, 80, 85, 87, 88	34, 35, 42, 54, 55, 59, 65, 69,
Burke 30, 63, 65, 72, 84, 85	70, 72, 79, 87
Cabarrus 36, 83	Madison 35, 43, 54, 59, 65
Caldwell 20, 30, 84	Martin 46
Carteret 28, 52, 76, 89	Mecklenburg 28, 36, 65, 83
Caswell 1	Mitchell 14, 15, 18, 20, 25, 51,
Chatham 36, 67	53, 54, 55, 57, 58, 65, 70, 78,
Cherokee 29, 59, 75	84, 85, 90
Clay 8, 11, 12, 19, 20, 28,	Montgomery 49, 81, 83
30, 59	Moore 36, 49, 52, 61, 65, 68, 71
Cleveland 39	Nash 9, 27, 28, 38
Columbus 13, 49, 52, 62, 73, 83,	New Hanover 4, 17, 45, 49, 52, 76, 91
91	Northampton 21
Craven 3, 9, 17, 28, 41, 52, 64,	Onslow 13, 45, 49, 52, 73, 91
91	Orange 36, 61, 65, 81
Cumberland 36, 38, 49, 52, 68, 73,	Pamlico 29, 52, 73, 89
82, 91	Pender 27, 28, 29, 45, 49, 52, 62,
Currituck 66	68, 73, 89, 91
Dare 66	Person 38
Davidson 77	Pitt 9
Davie 61	Polk 60, 65, 80, 87
Duplin 9, 13, 38, 49, 52	Randolph 61
Durham 36, 38, 61, 65, 81	Richmond 49, 62, 68, 73
Edgecombe 28	Robeson 13, 29, 49, 52, 61, 62
Forsyth 28, 29, 30, 36, 40, 48	Rowan 1, 29, 36, 40, 42, 83
Franklin 1, 36, 40, 61	Rutherford 16, 36, 50, 54
Graham 20, 28, 54, 59	Sampson 9, 13, 38, 52, 91
Granville 38, 40, 67	Scotland 9, 13, 49, 62, 68, 73
Greene 13	Stanly 2, 28, 36, 77, 83
Guilford 28, 36	Stokes 48, 58
Halifax 44	Surry 31
Harnett 9, 31, 36, 38, 49, 62, 71,	Swain 10, 18, 20, 35, 54, 59, 65,
82, 86, 91	69, 72, 74, 79, 85
Haywood 16, 18, 19, 20, 28, 30, 34,	Transylvania 5, 8, 18, 24, 30, 32,
35, 55, 59, 65, 70, 79, 85	56, 65, 70, 72, 85

Table 1. Continued.

Union 83	Watauga 25, 54, 57, 58, 70, 84, 85,
Vance 38	90
Wake 1, 27, 30, 36, 38, 40, 61, 65	Wayne 49
Warren 30	Wilson 28, 61
	Yancey 18, 20, 25, 34, 54, 78, 85

Table 2. Vascular plants of primary concern. Letter following the common name denotes status; see key below. Number following letter refers to species account number in text.

KEY: A = Extinct or extirpated E = Threatened endemic B = Endangered endemic F = Threatened throughout C = Endangered throughout G = Threatened disjunct D = Endangered disjunct H = Exploited	
Species	Common Name
<i>Arenaria godfreyi</i>	Godfrey's sandwort C 41
<i>Arenaria uniflora</i>	Single-flowered sandwort C 42
<i>Asplenium heteroresiliens</i>	Carolina spleenwort fern C 4
<i>Asplenium monanthes</i>	Single-sorus spleenwort fern D 5
<i>Astilbe crenatiloba</i>	Roan false goat's-beard A 53
<i>Betula papyrifera</i> var. <i>cordifolia</i>	Mountain paper birch D 34
<i>Buckleya distichophylla</i>	Piratebush C 35
<i>Cacalia rugelia</i>	Rugel's ragwort B 79
<i>Calamagrostis porteri</i>	Porter's reedgrass G 8
<i>Calamovilfa brevipilis</i>	Riverbank sandreed F 9
<i>Cardamine micranthera</i>	Small-anthered bittercress A 48
<i>Carex aenea</i>	Fernald's hay sedge D 15
<i>Carex biltmoreana</i>	Biltmore sedge C 16
<i>Carex chapmanii</i>	Chapman's sedge F 17
<i>Carex misera</i>	Wretched sedge B 18
<i>Carex purpurifera</i>	Purple sedge B 19

Table 2. Continued.

<i>Cladrastis lutea</i>	Yellowwood FH 59
<i>Coreopsis latifolia</i>	Broadleaf coreopsis B 80
<i>Cymophyllus fraseri</i>	Fraser's sedge F 20
<i>Cystopteris X tennesseensis</i>	Tennessee bladder fern D 3
<i>Dalibarda repens</i>	Robin-run-away D 56
<i>Diervilla rivularis</i>	Georgia bush-honeysuckle F 78
<i>Dionaea muscipula</i>	Venus' fly-trap EH 52
<i>Echinacea laevigata</i>	Smooth coneflower F 81
<i>Eriocaulon lineare</i>	Linear pipewort G 22
<i>Eupatorium resinosum</i>	Resinous joe-pie-weed G 82
<i>Gale palustris</i>	Sweet gale A 33
<i>Geum geniculatum</i>	Bent avens B 57
<i>Geum radiatum</i>	Spreading avens B 58
<i>Glyceria nubigena</i>	Smoky-mountain mannagrass B 10
<i>Grammitis nimbata</i>	Dwarf polypody fern D 6
<i>Habenaria flava</i>	Southern rein-orchid F 28
<i>Habenaria integra</i>	Yellow fringeless-orchid F 29
<i>Habenaria peramoena</i>	Purple fringeless-orchid F 30
<i>Helianthus schweinitzii</i>	Schweinitz' sunflower E 83
<i>Helonias bullata</i>	Swamp-pink F 24
<i>Hexastylis contracta</i>	Mountain heart leaf C 37
<i>Hexastylis lewisii</i>	Lewis' heart leaf E 38
<i>Hexastylis naniflora</i>	Dwarf-flowered heart leaf B 39
<i>Hudsonia montana</i>	Mountain golden heather B 63
<i>Hydrastis canadensis</i>	Goldenseal FH 43
<i>Ilex amelanchier</i>	Sarvis holly F 62
<i>Isoetes piedmontana</i>	Piedmont quillwort F 1
<i>Isotria medeoloides</i>	Small whorled pogonia C 31
<i>Juncus trifidus</i> var. <i>monanthos</i>	One-flowered rush D 23
<i>Kalmia cuneata</i>	White wicky B 68
<i>Iiatris helleri</i>	Heller's gayfeather F 84
<i>Lilaeopsis carolinensis</i>	Carolina lilaeopsis C 66
<i>Lilium grayi</i>	Gray's lily FH 25
<i>Lindera melissaefolia</i>	Southern spicebush C 47
<i>Lindernia saxicola</i>	Rock false pimpernel A 75
<i>Listera cordata</i>	Heart-leaved twayblade D 32
<i>Lysimachia asperulaefolia</i>	Rough-leaf loosestrife B 73
<i>Myriophyllum laxum</i>	Loose watermilfoil F 64
<i>Nartheceium americanum</i>	Bog asphodel F 26
<i>Nestronia umbellula</i>	Nestronia F 36
<i>Panax quinquefolium</i>	Ginseng FH 65
<i>Pallaea X wrightiana</i>	Wright's cliff-brake fern D 2
<i>Plantago cordata</i>	Heart-leaf plantain C 77
<i>Poa languida</i>	Torrey bluegrass D 11
<i>Portulaca smallii</i>	Small's portulaca C 40
<i>Prenanthes roanensis</i>	Roan rattlesnakeroot F 85
<i>Psoralea macrophylla</i>	Bigleaf scurfpea A 60
<i>Ptilimnium fluviatile</i>	Stream mockbishopweed F 67
<i>Pyxidanthera barbulata</i> var. <i>brevifolia</i>	Wells' pyxie-moss B 71
<i>Ranunculus subcordatus</i>	Bladen buttercup B 44

Table 2. Continued.

<i>Rhododendron bakeri</i>	Cumberland azalea	FH	69
<i>Rhododendron vaseyi</i>	Pink-shell azalea	EH	70
<i>Rhus michauxii</i>	Michaux sumac	F	61
<i>Rudbeckia heliopsidis</i>	Sun-facing coneflower	F	86
<i>Sagittaria fasciculata</i>	Bunched arrowhead	B	7
<i>Sarracenia rubra</i>	Sweet pitcher-plant	FH	49
<i>Saxifraga careyana</i>	Carey saxifrage	F	54
<i>Saxifraga caroliniana</i>	Carolina saxifrage	C	55
<i>Schisandra glabra</i>	Magnoliavine	F	46
<i>Scirpus flaccidifolius</i>	Reclining bulrush	B	21
<i>Sedum pusillum</i>	Puck's orpine	C	50
<i>Sedum rosea</i>	Roseroot	D	51
<i>Senecio millefolium</i>	Divided-leaf groundsel	C	87
<i>Shortia galacifolia</i>	Oconee bells	BH	72
<i>Solidago porteri</i>	Porter's goldenrod	A	88
<i>Solidago pulchra</i>	Carolina goldenrod	B	89
<i>Solidago spithamea</i>	Blue-ridge goldenrod	B	90
<i>Solidago verna</i>	Spring-flowering goldenrod	B	91
<i>Sporobolus heterolepis</i>	Prairie dropseed	D	12
<i>Sporobolus teretifolius</i>	Wireleaf dropseed	F	13
<i>Synandra hispidula</i>	Synandra	F	74
<i>Thalictrum cooleyi</i>	Cooley's meadowrue	B	45
<i>Trillium pusillum</i> var. <i>pusillum</i>	Carolina trillium	F	27
<i>Trisetum spicatum</i> var. <i>molle</i>	Soft trisetum	D	14
<i>Utricularia olivacea</i>	Dwarf bladderwort	F	76

TOTALS: 91 species -- 6 Extinct, 20 Endangered endemic, 14 Endangered throughout, 13 Endangered disjunct, 4 Threatened endemic, 31 Threatened throughout, 3 Threatened disjunct, and 9 Exploited.

SPECIES ACCOUNTS

ISOETACEAE
(Quillwort Family)

1. *Isoetes piedmontana* (Pfeiffer) Reed PIEDMONT QUILLWORT

Description: A "grasslike," semiaquatic herb with a short, fleshy, underground stem. The leaves are round, hollow, and divided into four transversely separated longitudinal chambers. Male and female sporangia are borne separately in the dilated leaf bases. The male spores are minute, the female spores as large as grains of sand and ornamented with crests and ridges, often wartlike. Maturation of spores occurs May to October, but vegetative growth begins during the winter wet season.

Distribution: Range -- the Carolinas and Georgia.
North Carolina -- Caswell, Franklin, Rowan, and Wake counties.

Habitat: Temporary pools and drainage margins on granite outcrops.

Status: *Threatened* throughout. This species is an endemic on the granite outcrops that occur in the Piedmont of the southeast. These outcrops have been the primary source of gravel for highway construction, and are also a favorite area for motorcycles and trail bikes, which cause habitat destruction. The temporary pools, specific habitat of the species, are particularly easily destroyed.

Remarks: The Piedmont Quillwort was included under *I. melanopoda* Gay and Durieu in the Manual, p. 8. It has been treated subsequently as the eastern counterpart of *I. melanopoda*, which is west of the Mississippi River.

References: Reed, C. F. 1965. *Isoetes* in southeastern United States. *Phytologia* 12:369-400.
Matthews, J. F., and W. H. Murdy. 1969. A study of *Isoetes* common to the granite outcrops of the southeastern Piedmont, United States. *Bot. Gaz.* 130:53-61.

PTERIDACEAE
(Bracken-fern Family)

2. *Pellaea X wrightiana* Hooker

WRIGHT'S CLIFF-BRAKE FERN



Description: An herbaceous fern with evergreen, erect leaves, twice-pinnately divided, stiff and brittle, light green with purple brown stalks. The sterile leaves are flat, and the fertile leaves narrower with the margins of the leaflets rolled under and covering the sporangia. May to September. (Man. p. 18). Fig. 4, UNC Press.

Distribution: Range — Arizona, New Mexico, Oklahoma, Texas, and N Mexico.

North Carolina — Piedmont; Alexander and Stanly cos.

Habitat: Crevices of granite outcrops.

Status: *Endangered* disjunct. These two North Carolina locations represent a most remarkable east-west disjunction of 1,280 to 1,600 km (800 to 1,000 mi.) from Oklahoma and Texas. The outcrops where the fern occurs are delicate habitats and easily destroyed.

Remarks: The Alexander County location was discovered in 1956 and revisited in 1964. The Stanly County population was discovered in 1975. These eastern disjuncts are probably due to long-range wind dispersal of minute spores which are capable of establishing new plants.

Reference: Wagner, W. H., Jr. 1965. *Pellaea wrightiana* in North Carolina and the question of its origin. J. Elisha Mitchell Sci. Soc. 81:95-103.

ASPIDIACEAE
(Shield-fern Family)

3. *Cystopteris X tennesseensis* Shaver

TENNESSEE BLADDER FERN



Description: A rhizomatous herb with leaves arching or pendent, deciduous. The leaf petioles are dark brown at the base, becoming straw colored. The blades are 2 to 3 times divided, to 31 cm (12 in.) long and 18 cm (7 in.) wide, and bulblets are absent or present along the leaf axis. Spores form in round clusters (sori) April to June. The indusium is thin and pocketlike or cup shaped. (Man. p. 23). Fig. 5, SIU Press.

Distribution: Range — Kentucky, North Carolina, and Tennessee.

North Carolina — outer Coastal Plain; Craven and Jones counties.

Habitat: Marl outcrops.

Status: *Endangered* disjunct. The North Carolina populations represent a disjunction of some 640 km (400 mi.) from the normal range on the Cumberland Plateau.

Remarks: This species is believed to have originated as a hybrid between *C. bulbifera* and *C. protrusa*, neither of which occurs on the Coastal Plain.

References: Mohlenbrock (1967); see list following introduction.

ASPLENIACEAE
(Spleenwort Fern Family)

4. *Asplenium heteroresiliens* W. H. Wagner

CAROLINA SPLEENWORT FERN

Description: A small fern with a short creeping rhizome. The leaves are erect to spreading slightly, coriaceous, and pinnately compound. The blades are to 3 dm (11 3/4 in.) long and 2.5 cm (1 in.) wide, with leaflets opposite, and auricled on the upper side. Spores are formed April to October. (Man. p. 30). The species is similar to *A. resiliens*, but the pinnae are crenulate on the upper margins.

Distribution: Range -- North Carolina; Columbia, Jackson and Liberty cos., Florida; Berkeley Co., South Carolina.
North Carolina -- Coastal Plain; Bladen, Jones, and New Hanover cos.

Habitat: Shaded marl outcrops.

Status: *Endangered* throughout. This fern is a highly restricted endemic in the southeastern United States, known only from very small populations in a few localities.

References: Wagner, W. H. 1966. Two new species of ferns from the United States. *Amer. Fern J.* 56:3-17.

5. *Asplenium monanthos* L.

SINGLE-SORUS SPLEENWORT FERN

Description: An evergreen, erect fern with once-divided leaves, 15 to 30 cm (6 to 12 in.) long and to 2 cm (3/4 in.) wide. The leaflets or pinnae are opposite and short stalked, oblong, and toothed along the upper margin only, and with the main vein along the lower margin. Clusters of sporangia are usually solitary or occasionally two on the back of the pinna, parallel to the main vein, and occurring from April into October. (Man. p. 32).

Distribution: Range -- North Carolina, adjacent Oconee Co., South Carolina, Florida, Arizona, Mexico; south to Chile, widespread through tropics.

North Carolina -- mountains; Transylvania Co.

Habitat: Shaded, moist, granite boulders, and steep, rocky bluffs in cool, shaded ravines near rivers and waterfalls.

Reproduction: Apomictic development of spores.

Status: *Endangered* disjunct. This fern is one of the most interesting in the state in terms of its geographical affinities with the southwestern United States and Mexico. It occurs in a few localities in the river gorges of the Blue Ridge Escarpment, in delicate habitats threatened by the pressures of tourist traffic and river impoundment.

References: Wagner, W. H., D. R. Farrar, and B. W. McAlpin. 1970. Pteridology of the Highlands Biological Station area, southern Appalachians. *J. Elisha Mitchell Sci. Soc.* 86:1-27.

GRAMMITIDACEAE
(Dwarf Polypody Family)

6. *Grammitis nimbata* (Jenm.) Proctor

DWARF POLYPODY FERN

Description: A fern with minute rhizome, creeping, and attached to moss and rocks. The leaves are deeply lobed, less than 3 cm (1 1/8 in.) long and 1 cm (3/8 in.) wide, at spaced intervals along the stem, and covered with dark brown hairs. The plants do not produce spores in the North Carolina populations. (Man. pp. 33-34).

Distribution: Range -- West Indies and North Carolina.
North Carolina -- mountains; Macon Co.

Habitat: Known only from the moss mats in the grottos back of Dry Falls.

Status: *Endangered* disjunct. The Macon County site is the only location known in North America, and easy access to the plants is afforded by a trail. Although most people would not recognize this fern, the habitat is easily destroyed by activities of heavy pedestrian traffic. A recent observation that the spray was being deflected by ice forming on a chain link fence has led to a question of the effects this might have on the population.

References: Wagner, W. H., D. R. Farrar, and B. W. McAlpin. 1970. Pteridology of the Highlands Biological Station area, southern Appalachians. J. Elisha Mitchell Sci. Soc. 86:1-27.



ALISMATACEAE
(Water-plantain or Arrowhead Family)

7. *Sagittaria fasciculata* E. O. Beal BUNCHED OR
CLUSTERED ARROWHEAD

Description: An aquatic herb with emersed, basal, long-stalked leaves to 3 dm (12 in.) long and 2 cm (3/4 in.) wide, without basal lobes. The flowering stalk is erect, with upper flowers male and lower flowers female. Male flowers have 3 reflexed sepals, 3 white petals, and numerous stamens with pubescent, dilated filaments. Female flowers have 3 spreading or reflexed sepals, 3 white petals, and numerous separate carpels. The stalks of the lowest whorl of flowers ascend in fruit, and the fruiting head is of numerous achenes. Flowering and fruiting occur May to July. (Man. p. 52). Fig. 6, Beal (1960).

Distribution: Range -- lower mountains of North Carolina, upper Piedmont of South Carolina.

North Carolina -- Buncombe and Henderson cos.

Habitat: Swamps, bogs, and sluggish streams.

Reproduction: May be limited to vegetative means; no seedlings have been found.

Status: *Endangered* endemic. This species is endemic to a very restricted area and limited to a few hundred plants. Much of an earlier population was eliminated by construction sites.

References: Beal, E. O. 1960. The Alismataceae of the Carolinas. J. Elisha Mitchell Sci. Soc. 76:68-79.



POACEAE or GRAMINEAE
(Grass Family)

8. *Calamagrostis porteri* A. Gray

PORTER'S
REEDGRASS

Description: A slender, loosely tufted, rhizomatous perennial, with stems 6 to 12 dm (23 to 46 in.) tall. The leaf blades are flat and spreading, with pubescent sheaths. The panicle is narrow, 10 to 15 cm (4 to 6 in.) long. The callus hairs are sparse and in two tufts. Flowering and fruiting occur July and August. Fig. 7, NYBG.

Distribution: Range -- mountains of North Carolina, New York, Pennsylvania, Virginia, and West Virginia.

North Carolina -- mountains;
Clay and Transylvania cos.

Habitat: Dry, rocky upland woods.

Status: *Threatened* disjunct. This plant is highly localized but fairly widespread, and is a species that seldom flowers or fruits.

References: Hitchcock (1950); see list following introduction. Fernald, M. L. 1950. Gray's Manual of Botany, 8th Ed. Amer. Book Co., Boston, MA.

9. *Calamovilfa brevipilis* (Torrey) Scribner

RIVERBANK SANDREED



Description: A densely tufted perennial with stems 7 to 12 dm (27 to 46 in.) tall. The leaves are primarily basal, with setaceous blades to 6 dm (23 in.) long and 1 to 5 mm wide. The sheaths are glabrous and the ligules erose-ciliate. The panicle is purplish, 2 to 4 dm (8 to 16 in.) long, 6 to 15 cm (2 3/8 to 6 in.) broad. The spikelets are brownish or purplish and the callus villous. Flowering and fruiting occur June to October. (Man. p. 112). Fig. 8, UNC Press.

Distribution: Range -- Coastal Plain of the Carolinas and New Jersey.

North Carolina --

Brunswick, Craven, Duplin, Harnett,

Johnson, Nash, Pitt, Sampson, and Scotland cos.

Habitat: Bogs and savannahs.

Status: *Threatened* throughout. This species is a localized disjunct dependent on fire or management for its continued existence.

10. *Glyceria nubigena* W. A. Anderson

SMOKY MOUNTAIN MANNAGRASS

Description: A short, rhizomatous perennial, with stems 8 to 14 dm (31 to 54 in.) tall. The leaf blades are 4.5 dm (17 1/2 in.) long, 5 to 10 mm wide. The panicles are open, 2 to 3 dm (8 to 11 3/4 in.) long, 2 to 2.5 dm (8 to 9 3/4 in.) broad, branches spreading. The spikelets are 2-3 flowered. Flowering in June and July. (Man. p. 81).

Distribution: Range -- western mountains of North Carolina, Great Smoky Mountains of Tennessee.

North Carolina -- Avery and Swain cos.

Habitat: Seepage areas on balds and high ridges.

Status: *Endangered* endemic. This grass occurs in small populations and has a very limited distribution.

References: Anderson, W. A. 1933. A new species of *Glyceria* from the Great Smoky Mountains. *Rhodora* 35:320-322.

11. *Poa languida* Hitchcock

TORREY BLUEGRASS



Description: A tufted perennial with weak stems 3 to 9 dm (11 3/4 to 35 in.) tall. The leaves are lax and grass like, the narrow blades to 10 cm (4 in.) long and 1 to 4 mm wide. The flowers are borne in the axils of scales, perianth absent, 2-4 per spikelet. The spikelets are in a nodding panicle, the branches slender. The lowest scale (glume) is 1-nerved, rough to the touch and apically keeled, and the 2nd glume is 3-nerved and keeled. The scales or lemmas subtending each floret are 5-nerved and with a cottony web at the base. The fruit is a yellowish grain. Flowering occurs April through May. (Man. p. 78). Fig. 9, NYBG.

Distribution: Range -- North Carolina, Kentucky, Pennsylvania, Iowa, Wisconsin, north into Canada.

North Carolina -- mountains; Clay Co.

Habitat: Sandy or rocky woods and ridges throughout its range, but only in pine barrens over olivine in North Carolina.

Status: *Endangered* disjunct. The North Carolina population is disjunct from Kentucky, and the population at Buck Creek, Clay County, is its southernmost known location.

References: Hitchcock (1950); see list following introduction.

12. *Sporobolus heterolepis* Gray

PRAIRIE OR
NORTHERN DROPSEED



Description: A tufted, perennial grass having stems 4 to 8 dm (15 1/2 to 31 in.) tall, with nodes and internodes not hairy. The leaves are basal, low on the stem, and smooth or slightly rough above, below, and on the margins. The spikelets are dark, 1-flowered and arranged in a dark green, open panicle with ascending, alternate branches. The lowest glume is almost reduced to a rough-tipped awn, the 2nd is conspicuously nerved and not hairy. The lemmas are 1-nerved and smooth. No long awns are present. The seed is loose in the seed coat, and the fruit is a utricle. Flowering and fruiting occur August and September. (Man. p. 105). Fig. 10, USDA.

Distribution: Range -- Canada south to Connecticut, Pennsylvania west to Illinois, North Carolina, Georgia, Arkansas, Texas, and Wyoming.

North Carolina -- mountains;
Clay Co.

Habitat: Outside North Carolina this grass is found on limestone and serpentine, but here it occurs in pine barrens over olivine.

Reproduction: The grain has not been seen in specimens from this state, and the sexual reproduction may be sporadic or reproduction may be almost entirely vegetative.

Status: *Endangered* disjunct. This is a very rare disjunct, in danger of extirpation because of its very limited distribution in only one county and its restriction to a very limited habitat.

13. *Sporobolus teretifolius* Harper

WIRELEAF DROPSEED



Description: A densely tufted perennial, 6 to 10 dm (23 1/2 to 39 in.) tall, with basal, narrow, grass-like leaves. The flowers are without a perianth and borne in 1-flowered spikelets in the axils of scales. The spikelets are in open panicles, 1 to 5 dm (4 to 19 1/2 in.) long, with the panicle branches alternate and ascending. The spikelets are lustrous, brownish or purplish. The lower-most glume of the spikelet is faintly nerved and keeled, and the 2nd is 3-7 nerved. The fruit is a yellowish, obovoid grain. Flowering and fruiting occur August to September. (Man. p. 104). Fig. 11, USDA.

Distribution: Range -- the Carolinas and Georgia.

North Carolina -- Coastal Plain; Bladen, Brunswick, Columbus, Duplin, Green, Jones, Lenoir, Onslow, Robeson, Sampson, and Scotland cos.

Habitat: Savannas and moist pine barrens.

Status: *Threatened* throughout. This rare species is restricted to the Coastal Plain of the Carolinas and Georgia. It is threatened by the rapid destruction of its habitats, and habitat preservation is needed for it to survive in this state.

References: Hitchcock (1950); see list following introduction.

14. *Trisetum spicatum* var. *molle* (Michaux)
Beal SOFT TRISETUM



Description: A tufted, perennial grass having stems 1 to 4 dm (4 to 15 1/2 in.) tall, with hairy nodes and internodes. The narrow leaves are mostly basal, rough above and hairy below, with ciliate margins and hairy sheaths. The spikelets have 2 flowers and are arranged in a dense, narrow, spike-like panicle that is silvery green. The glumes are 3-5 nerved, keeled, hairy to smooth, with a long awn arising from above the middle of the lemma. Flowering and fruiting occur June to August. (Man. p. 91). Fig. 12, USDA.

Distribution: Range -- western North Carolina; Pennsylvania west to Colorado and California; north into Canada.

North Carolina -- Roan Mountain, Mitchell Co.

Habitat: Rocky ledges.

Reproduction: The grain has not been seen in specimens from North Carolina, and the sexual reproduction may be sporadic or reproduction may be almost entirely vegetative.

Status: *Endangered* disjunct. This species is separated from its nearest populations by over 960 km (600 mi.). It is in danger of extirpation here because of its precarious habitat and restricted distribution.

CYPERACEAE
(Sedge Family)

15. *Carex aenea* Fernald

FERNALD'S HAY SEDGE



Description: A perennial, nodding sedge, 4 to 7 dm (15 1/2 to 27 in.) tall, having triangular stems and 3-ranked leaves with narrow blades. The spikes are sessile and may be closely grouped or separated, with the female flowers above the male. The papery sheath surrounding the nutlet (perigynium) is lustrous brown at maturity, flat, with winged margins, a nonspongy base, and a toothed, bidentate beak. The scales of the female flowers are as long as the perigynia and as wide above. The nutlets are yellowish to brownish lenticular (bi-convex), with 2 style branches. Flowering and fruiting occur June and July. (Man. p. 228). Fig. 13, NYBG.

Distribution: Range -- North Carolina; Pennsylvania and New York, west to South Dakota and Montana; north into Canada and E Alaska.
North Carolina --
Roan Mountain, Mitchell Co.

Habitat: Grass balds.

Status: *Endangered* disjunct. This species is separated from its nearest populations by over 960 km (600 mi.). It is very rare on Roan Mountain and in danger of extirpation due to man's influence in changing the character of the natural grass balds.

16. *Carex biltmoreana* Mackenzie

BILTMORE SEDGE



Description: A loosely clumped herb with slender, underground rhizomes and upright stems 3 to 5 dm (11 3/4 to 19 1/2 in.) tall. Female flowers occur in a few erect spikes below the male spikes. The scales of the spike are brownish, the nutlets 3-angled. Flowering and fruiting occur in May and June. (Man. p. 234). Fig. 14, NYBG.

Distribution: Range -- a few sites in mountains of Georgia, North Carolina, and Virginia.

North Carolina -- Buncombe, Haywood, Macon, and Rutherford cos.

Habitat: Rocky woods, rock crevices, and cliffs at high elevations.

Status: *Endangered* throughout. The few habitats in which the species occurs support very few plants, justifying its status. It occurs on National Forest lands at Fork Ridge, Haywood County, and National Park lands at Craggy Mountain.



17. *Carex chapmani* Steudel

CHAPMAN'S SEDGE

Description: A rhizomatous, loosely clumped herb with stems 1 to 4 dm (4 to 15 1/2 in.) tall. The male spike of flowers terminates the stem, and female spikes occur below, with dusty green perigynia enveloping the seeds. The nutlets are 3-angled. Flowering and fruiting occur in April and May. (Man. p. 234). Fig. 15, NYBG.

Distribution: Range -- Coastal Plain of the Carolinas, Florida, and Virginia. North Carolina -- Beaufort, Bladen, Craven, and New Hanover cos.

Habitat: Dry, sandy woods and roadsides.

Status: *Threatened* throughout. Chapman's Sedge is restricted in distribution and is not known to occur on public lands.

18. *Carex misera* Buckley

WRETCHED SEDGE



Description: A slender, perennial herb with stems 2 to 6 dm (7 3/4 to 23 1/2 in.) tall and narrow, grass-like leaves with flat, hairy blades. The flowers are unisexual and the perianth absent. The staminate flowers consist of 3 stamens in the axils of purplish or brownish scales, aggregated into a terminal spike on a peduncle. The pistillate spikes are 1-3, below the staminate, and vary from sessile to peduncled. The ovary is enclosed in a coarsely nerved, beakless or short-beaked perigynium. The pistillate scales are purplish or brownish, and obtuse. The fruit is an ellipsoidal to oblong nutlet on a distinct stalk. Fruiting occurs in June. (Man. p. 242). Fig. 16, NYBG.

Distribution: Range — Georgia, North Carolina, and Tennessee.

North Carolina — mountains; Ashe, Avery, Buncombe, Haywood, Macon, Mitchell (?), Swain, Transylvania, and Yancey cos.

Habitat: Rocky crevices and balds.

Status: *Endangered* endemic. This southern Appalachian species is apparently very rare, occurring at high elevations. Habitat preservation is imperative.

19. *Carex purpurifera* Mackenzie

PURPLE SEDGE



Description: A tufted, perennial herb, 3 to 4 dm (11 3/4 to 15 1/2 in.) tall, with mostly basal, grass-like leaves having purplish sheaths and narrow blades. The flowers are unisexual, perianth absent, in the axils of brownish or pale scales. The staminate spike is solitary and terminal, its peduncle wing-angled. The pistillate spikes are 2-4 and loosely flowered. The ovary is enclosed in a short, beaked perigynium. The pistillate scales are blunt at the apex but with a long projection or awn. The fruit is a tiny rounded nutlet. Flowering and fruiting occur in May and June. (Man. p. 238). Fig. 17, NYBG.

Distribution: Range — mountains of Georgia, Kentucky, North Carolina, and Tennessee.
North Caro-

lina — Ashe, Clay, Haywood, and Macon cos.

Habitat: Rich woods in mountain areas.

Status: *Endangered* endemic. Purple Sedge is a rare plant of the southern Appalachians and should be afforded every protection.

20. *Cymophyllus fraseri* (Andr.)
Mackenzie

FRASER'S SEDGE



Description: A tufted, perennial herb growing from short, thick rhizomes. The stems are to 3.5 dm (13 1/2 in.) tall. The leaves are evergreen and basal, the blades flat without an apparent midrib. The inflorescence is terminal and the spike has staminate flowers above the pistillate. The scales subtending each flower are white, the stamens conspicuous, and

the anthers white. A white perigynium encloses the ovary. Flowers in May and June. (Man. p. 217). Fig. 18, UNC Press.

Distribution: Range — mountains of the Carolinas, Pennsylvania, Tennessee, Virginia, and West Virginia.

North Carolina — Ashe, Avery, Caldwell, Clay, Graham, Haywood, Jackson, Macon, Mitchell, Swain, and Yancey cos.

Habitat: Rich woods and stream banks.

Status: *Threatened* throughout. Although widely scattered geographically, populations of this southern Appalachian endemic are usually localized. Fernald (1950) considers this to be a very primitive relict genus, and Fraser's Sedge is the only living member of the genus.

References: Clarkson, R. B. 1961. Fraser's sedge, *Cymophyllus fraseri* (Andr.) Mackenzie. *Castanea* 26:129-136.
Fernald, M. L. 1950. Gray's Manual of Botany, 8th Ed. Amer. Book Co., Boston, MA.

21. *Scirpus flaccidifolius* (Fern.) Schuyt. RECLINING BULRUSH
(*Scirpus atrovirens* Muhl. var. *flaccidifolius* Fern.)

Description: A rhizomatous, perennial herb with solitary, reclining, and lax stems. The leaves are translucent and membranaceous with mostly smooth sheaths. The inflorescence is terminal and umbellate, with the spikelets in clusters at the ends of the long primary inflorescence branches. The flowers are mostly perfect and borne in the axil of blackish ovate to orbicular scales. The perianth consists of 6 bristles which are frequently longer than the mature fruit, which is a tiny, pale to whitish nutlet.

Distribution: Range — southeastern Coastal Plain of Virginia (Greensville, Sussex, Southampton cos.), and adjacent North Carolina.
North Carolina — Northampton Co.

Habitat: Wet, swampy bottomlands and bottomland clearings.

Status: *Endangered* endemic. A very localized endemic known only from the four contiguous counties.

References: Fernald, M. L. 1938. Noteworthy plants of Southeastern Virginia. *Rhodora* 40:396.
Schuyler, A. E. 1967. A new status for an eastern North American *Scirpus*. *Rhodora* 69:198-202.

ERIOCAULACEAE
(Pipewort Family)

22. *Eriocaulon lineare* Small

LINEAR PIPEWORT

Description: A tall, slender herb with narrow, grass-like leaves to 7 cm (2 3/4 in.) long. The naked stems grow to 3 dm (11 3/4 in.) tall and are ridged. The flowers are minute, in a hemispheric head which is hairy, light gray or brownish. Flowering occurs April to July, (Man. p. 266).

Distribution: Range -- Alabama, Florida, Georgia, and North Carolina. North Carolina -- mountains; Henderson Co.

Habitat: Bogs, shallow pools, ditches, and savannahs.

Status: *Threatened* disjunct. The North Carolina locality represents a northern and inland disjunct population of a southern Coastal Plain species. It occurs in bogs which are being drained for development. The open bog habitat must be protected from drainage, and maintained by periodic fire or cutting to retard the natural encroachment of trees and shrubs.

Remarks: The North Carolina populations need to be examined thoroughly in view of the study by Kral (1966). The relationship between *E. lineare* and *E. septangulare* is particularly important in this recognition of rare, threatened species.

References: Kral, R. 1966. Eriocaulaceae of continental North America north of Mexico. *Sida* 2:285-332.

JUNCACEAE
(Rush Family)

23. *Juncus trifidus* L. var. *monanthos* (Jacquin) Bluff & Fing.

ONE-FLOWERED RUSH

Description: A perennial herb growing in clumps, with stems to 3 dm (11 3/4 in.) tall with flowers appearing terminal. The leaf blades are flat, and the bract at the base of the flower cluster exceeds the flowers. The flowers are 1-3, greenish, and the perianth is 6-parted. The beaked capsules are dark brown. The plants flower and fruit from June to September. (Man. p. 275).

Distribution: Range -- Appalachians; North Carolina, Tennessee, and Virginia, north to central New Hampshire.
North Carolina -- Craggy Mountain, Buncombe Co.

Habitat: Rock crevices at high elevations.

Status: *Endangered* disjunct. Few plants occur at the Craggy Mountain site, its southernmost station. It occurs here on National Park lands.

LILIACEAE
(Lily Family)

24. *Helonias bullata* L.

SWAMP-PINK



Description: A perennial herb growing to 3 dm (11 3/4 in.) from a stocky underground rhizome. The leaves are strap like, to 2.5 dm (9 3/4 in.) long, evergreen, and in a basal rosette. The flowers are in a terminal cluster, 3 to 8 cm long, each 6-parted, pink to lavender. The fruit is a 3-lobed capsule. Flowering occurs in April or May and fruiting in June and July. (Man. pp. 299-301). Fig. 19, UNC Press.

Distribution: Range — the Carolinas and Georgia, north in mountains to Pennsylvania; coastal Virginia and New York.

North Carolina — mountains; Henderson, Jackson, and Transylvania cos.

Habitat: Swamps and bogs. Colonies occasionally cover patches of mud, hence the probable derivation of the term "pink beds" in Transylvania County, North Carolina.

Reproduction: This plant apparently seldom forms seeds, can reproduce vegetatively, and is occasionally collected for gardens.

Status: *Threatened* throughout. Field investigators report the plant uncommon at all locations. Draining of its habitats continues. It occurs on public lands in Jackson and Transylvania counties.

References: McDowell, G. M. 1973. The swamp-pink, an unreported native of South Carolina. *Castanea* 38:407-408.

25. *Lilium grayi* Watson

GRAY'S LILY

Description: An erect, bulbous perennial with stems to 2 m (6 1/2 ft.) tall. The leaves are in whorls of 5-11, with blades 4 to 13 cm long. The margins and often the veins on the lower side are rough to the touch. The flowers number 1-7, are horizontal or slightly nodding, bell shaped, and the lobes are straight. The sepals and petals are red or reddish orange and spotted. There are 6 stamens. The fruit is a capsule. Flowering occurs in June and July. (Man. p. 311).

Distribution: Range — North Carolina, and adjacent Virginia and Tennessee.

North Carolina — mountains; Ashe, Avery, Buncombe, McDowell, Mitchell, Watauga, and Yancey cos. Some of these records may be based on plants from cultivation.

Habitat: Mountain balds, meadows, and forest openings.

Status: *Threatened* throughout, *Exploited*. This species is quite rare and populations are small and often widely separated. It is currently being exploited commercially and privately for garden use.

Remarks: This plant is also known as Roan Lily and Orange-bell Lily.

26. *Narthecium americanum* Ker

BOG OR YELLOW ASPHODEL



Description: A perennial herb growing from a slender rhizome, with stems to a height of 4 dm (15 1/2 in.). The leaves are narrow, mainly basal, and 1 to 2 dm (4 to 7 3/4 in.) long. The flowers are 6-parted, small, yellow, and clustered near the stem tip. The fruits are papery capsules. Flowering occurs in June and July and fruiting in August and September. (Man. p. 299). Fig. 20, UNC Press.

Distribution: Range — Delaware, New Jersey, North and South Carolina (Dorchester Co.).

North Carolina — mountains;
Henderson Co.

Habitat: Bogs and pocosins.

Status: *Threatened* throughout. The appropriate habitats are few and are being drained in many areas. It is not known to occur on public lands in North Carolina.

27. *Trillium pusillum* Michaux var. *pusillum*
(including var. *virginianum* Fernald)

CAROLINA OR
LEAST TRILLIUM



Description: A rhizomatous, perennial herb with slender, green stems, 0.5 to 3 dm (2 to 11 3/4 in.) tall. The leaves are green, not mottled, and sessile or on very short petioles. The flowers are erect, and sessile or on peduncles. The sepals are spreading, their apex blunt. The petals are white, pink or purplish, and lanceolate. The stamens have slender white filaments, the anthers are purple, and the stigmas and ovary are white. The fruit is an obscurely 3-angled berry. Flowering occurs March to May. (Man. p. 292). Fig. 21, NYBG.

Distribution: Range -- Maryland, Virginia, and the Carolinas.

North Carolina -- Coastal Plain and lower Piedmont;
cos.

Habitat: Moist woods, alluvial forests, pocosin borders, savannahs, and swamps.

Status: *Threatened* throughout. Although fairly widespread, this is a very rare plant and in need of protection.

ORCHIDACEAE
(Orchid Family)

28. *Habenaria flava* (L.) R. Brown
(*Platanthera flava* (L.) Lindl.)

SOUTHERN REIN-ORCHID



Description: A slender, erect herb, perennial from fleshy roots. The stem is 1.5 to 7 dm (6 to 27 in.) tall, with 1-5 dark green, strap-like leaves, clasping at the base. The yellowish or greenish flowers are small, irregular in shape, and spurred. The lip is lobed or angled at the base, with the margin neither fringed nor 3-parted at the apex. The fruit is a capsule. Flowering occurs June to October. (Man. p. 337). Fig. 22, NYBG.

Distribution: Range -- throughout eastern United States, into southeastern Canada.

North Carolina -- chiefly Coastal Plain, and over 900 m (3,000 ft.) elevation in southwestern mountains; Buncombe, Carteret, Clay, Craven, Edgecombe, Forsyth, Graham, Guilford, Haywood, Jackson, Johnston, Jones, Macon, Mecklenburg, Nash, Pender, Stanly, and Wilson cos.

Habitat: Swamp forest, alluvial woods, wet meadows, bogs, and swamps.

Status: *Threatened* throughout. This species is very widespread, but uncommon and threatened due to loss of available habitats.

Remarks: The Southern Rein-orchid is cultivated with difficulty due to attacks by soil fungi. The form found in the mountains and northward is considered to be the variety *herbiola* (Lindl.) Correll. The form in the Coastal Plain and Piedmont and southward is the typical variety. This plant is also known as the Pale-green, Southern Tubercled-, and Tubercled Rein-Orchid.

References: Luer (1975); see list following introduction.

29. *Habenaria integra* (Nutt.) Sprengel YELLOW FRINGELESS-ORCHID
(*Platanthera integra* (Nutt.) Gray ex Beck)



Description: An erect herb, perennial by fleshy roots, with a stem 3 to 6.2 dm (11 3/4 to 24 in.) tall. Leaves are several below, 10 to 19 cm (4 to 7 1/4 in.) long, 1 to 3 cm or more wide, and bract-like above. The flowers are irregular shaped and spurred, and light lemon orange, bright saffron yellow, to dull orange in color. The lip is entire or shallowly round-toothed, not 3-parted. The fruit is a capsule. Flowering occurs July to September. (Man. p. 337). Fig. 23, NYBG.

Distribution: Range -- central Florida west to E Texas, north to central Tennessee and S New Jersey.

North Carolina -- southern mountains, central Piedmont, and southeastern Coastal Plain; Brunswick, Cherokee, Forsyth, Henderson, Pamlico, Pender, Robeson, and Rowan cos.

Habitat: Swamps, pine barrens, and flatwoods.

Status: *Threatened* throughout. Although widespread in distribution this orchid is rare and threatened by elimination of habitats.

References: Luer (1975); see list following introduction.

30. *Habenaria peramoena* Gray
(*Platanthera peramoena* Gray)

PURPLE FRINGELESS-ORCHID OR
PRIDE-OF-THE-PEAK



Description: A stout, erect herb, perennial by fleshy roots, with a stem to 10.5 dm (41 in.) tall. The leaves are 2-5, erect, 7 to 20 cm (2 3/4 to 8 in.) long, with sheathing at the base. The violet purple flowers are irregular shaped and spurred, with 3-lobed lip. The terminal lobe is notched, not fringed, but minutely toothed. The fruit is a capsule. Flowering occurs June to October. (Man. p. 335). Fig. 24, NYBG.

Distribution: Range -- W South Carolina to E Arkansas and Missouri, northeastward to W New York and S New Jersey.

North Carolina -- mountains and Piedmont; Avery, Buncombe, Burke, Caldwell, Clay, Forsyth, Haywood, Henderson, Jackson, Macon, Transylvania, Wake, and Warren cos.

Habitat: Moist meadows and wooded slopes, swamps, and stream banks to 750 m (2,500 ft.) elevation in the mountains.

Status: *Threatened* throughout. This orchid is widespread but uncommon, and occurs in habitats being destroyed by development.

Remarks: The species is sometimes cultivated but susceptible to fungus attack. It is a beautiful plant which is sometimes dug and transplanted to private gardens, usually without success.

References: Luer (1975); see list following introduction.



31. *Isotria medeoloides* (Pursh) Raf.

SMALL WHORLED POGONIA

Description: A slender, perennial herb, 9.5 to 25 cm (3 3/4 to 10 in.) tall, with slender, fibrous, hairy roots. The stem is hollow, and greenish or purplish tinged. There are 5 or 6 leaves in a whorl at the top of the stem. They are pale dusty green and glaucous, elliptic to elliptic-ovate, and drooping. There are 1 or 2 irregular-shaped, yellowish green flowers terminating the stem. The sepals are linear oblong, and the petals oblanceolate and pale green. The lip is greenish white, veined with green, obovate, and 3-lobed. The white column is terete, the anther white, terminal, and hinged. The erect capsule is ellipsoid. Flowering occurs in May and June. (Man. p. 342). Fig. 25,

modified from NYBG.

Distribution: Range -- New England south to North Carolina; also Missouri, Illinois, and Michigan.

North Carolina -- one county in each physiographic province; Harnett, Henderson, and Surry cos.

Habitat: Open, dry, deciduous woods and along streams.

Reproduction: This plant has not been successfully cultivated or transplanted because slight root injury permits the entrance of destructive fungi.

Status: *Endangered* throughout. This is one of the rarest orchids in the United States. Populations are extremely small and very widely scattered. In 1924, only 17 locations were known nationwide. Since then many have been destroyed, and only a few new sites have been reported.

Remarks: The plants will often remain dormant underground and send up no leaves or flowers for a long period of time. Ten to twenty years may elapse between flowerings. The species is also known as the Small Whorled Crest-lip and the Green Five-leaved Orchid.

References: Luer (1975); see list following introduction.
Correll, D. S. 1950. Native Orchids of North America north of Mexico. Chronica Botanica Co., Waltham, MA. 399 pages.

32. *Listera cordata* (L.) R. Brown

HEART-LEAVED TWAYBLADE



Description: A slender, delicate, herbaceous orchid with few fibrous roots, which grows to a height of 25 cm (10 in.). There are two leaves, opposite, simple, and midway up the stem, broadly to narrowly heart shaped. The flowers are narrow, irregular shaped, purplish to yellowish green, and the lip is deeply cleft with narrow lobes. Flowering occurs in June and July. (Man. p. 340).
Fig. 26, NYBG.

Distribution: Range -- North Carolina, West Virginia, Virginia (Giles Co.), Maryland, northward into Canada, circumboreal.

North Carolina -- mountains;
Avery and Transylvania cos.

Habitat: Mossy forest floor and wooded acid bogs.

Status: *Endangered* disjunct. This is the most widespread of the Twayblades and one of the most widely distributed of all orchids, but it is still difficult to find anywhere. The mountain locations represent the southernmost disjuncts of this circumboreal species. They occur in areas easily eliminated by highways and resort developments. The Avery County population has not been seen for nearly a hundred years.

References: Luer (1975); see list following introduction.

MYRICACEAE
(Bayberry Family)

33. *Gale palustris* (Lam.) Chev.
(*Myrica gale* L.)

SWEET GALE



Description: A deciduous, dioecious shrub which grows to 1.5 m (5 ft.) tall. The leaves are alternate, simple, 3 to 6 cm long and to 1.8 cm wide, toothed above the middle, and resinous dotted. The flowers are small, in compact clusters, and appear in April before the leaves. The nuts are winged. (Man. p. 360).
Fig. 27, NYBG.

Distribution: Range -- circum-boreal, Canada south to New York, Pennsylvania, Michigan, North Carolina.
North Carolina -- mountains; Henderson Co.

Habitat: Bogs and pond borders.

Status: *Extirpated*. This disjunct population of a northern species was last seen in North Carolina in 1969, although it has been searched for in more recent years. It has probably been extirpated from this southern locality by the destruction of its boggy habitat.

Remarks: Sweet Gale is also known as Bog-myrtle and Meadow-fern.

BETULACEAE
(Birch Family)

34. *Betula papyrifera* var. *cordifolia* (Regel.) Fernald
(*Betula cordifolia* Regel) MOUNTAIN PAPER BIRCH



Description: A deciduous tree attaining heights of 10 m (33 ft.), with white or brownish bark peeling in thin sheets horizontally around the trunk. The leaves are alternate, heart shaped, toothed on the margin, and to 10 cm (4 in.) long and 8 cm wide. It is monoecious, with small flowers lacking petals, in compact catkins. The pollen catkins are long and slender, appearing in the fall before spring flowering. The fruiting catkins are cylindric and conelike, persisting into August. (Man. p. 368). Fig. 28, UNC Press.

Distribution: Range -- North Carolina; upper New York, Michigan, and Iowa, northward into Canada.

North Carolina -- mountains; Buncombe, Haywood, Macon, and Yancey cos.

Habitat: High altitude fir forests in moist or dry, rocky soil.

Status: *Endangered* disjunct. The rare occurrence in North Carolina represents a southern disjunction from the main distribution, which is in the eastern boreal forest, and the midwest. The locations in our mountains are endangered by recreational facilities and resorts.

Remarks: Recent arguments have shown that this is a species distinct from the typical paper birch, although the two hybridize in areas of overlapping distribution.

References: Hardin, J. W. 1971. Studies of the Southeastern United States Flora. I. Betulaceae. J. Elisha Mitchell Sci. Soc. 87:39-41.

SANTALACEAE
(Sandalwood Family)

35. *Buckleya distichophylla* (Nuttall) Torrey PIRATEBUSH OR BUCKLEYA



Description: A dioecious shrub with many clumped stems, or a small tree to 6 m (19 to 20 ft.) tall. The leaves are simple, distichous, opposite, lanceolate, 3 to 7 cm long, and sessile or short-petiolate. The greenish flowers are small, staminate in umbels, and pistillate solitary. There are 4 sepals, no petals, 4 stamens, and a single pistil. The ovary is inferior; the drupe is greenish and ellipsoid. Flowering occurs in April and May, fruiting in August. (Man. p. 396). Fig. 29, UNC Press.

Distribution: Range -- North Carolina, adjacent Tennessee, Virginia.

North Carolina -- mountains; Buncombe, Haywood, Macon, Madison, and Swain cos.

Habitat: Openings in hemlock stands, usually parasitic on the roots of Canadian hemlock.

Status: *Endangered* throughout. Piratebush is a very rare southern Appalachian endemic found in a very restricted habitat. Most of the plants that have been collected and observed are staminate; fruits have seldom been seen or collected. A fungal parasite seems to have destroyed many of the stems in the few known colonies during 1974-75.



36. *Nestronia umbellula* Raf.
NESTRONIA OR BOG ASPHODEL

Description: A low, dioecious colonial shrub, 0.5 to 1.5 m (1 1/2 to 5 ft.) tall. The leaves are simple, opposite, ovate to lanceolate, 3 to 6 cm long, with short petioles. The greenish flowers are small, staminate in umbels, pistillate solitary. The calyx is 4-5 lobed, petals are absent, stamens

number 4 or 5, and there is a single pistil. The ovary is inferior, the drupe greenish and subglobose to ovoid. Flowering occurs in April and May, fruiting in July. (Man. p. 396). Fig. 30, UNC Press.

Distribution: Range -- the Carolinas, Virginia, Georgia, Alabama.

North Carolina -- Piedmont; Cabarrus, Chatham, Cumberland, Durham, Forsyth, Franklin, Guilford, Harnett, Iredell, Mecklenburg, Moore, Orange, Rowan, Rutherford, Stanly, and Wake cos.

Habitat: Dry woodlands, usually parasitic on the roots of oaks and pines.

Status: *Threatened* throughout. The species is a southeastern Piedmont endemic that seldom fruits. Most of the colonies observed and collected are staminate. The county records indicate a widespread species, but the plant is rare and becoming increasingly moreso with construction and disturbance in the Piedmont province.

ARISTOLOCHIACEAE
(Birthwort Family)

37. *Hexastylis contracta* Blomquist

MOUNTAIN HEART LEAF

Description: A stemless, rhizomatous, perennial herb, with leathery, evergreen, and heart-shaped to rounded leaves, 4 to 7 cm long, which are not variegated. The flower is solitary, under leaves and litter, flask-shaped, contracted above the base, and with the 5 lobes ascending. Flowering occurs in June. (Man. p. 400).

Distribution: Range -- North Carolina, Cumberland Mountains of Tennessee.

North Carolina -- mountains; Buncombe and Henderson cos.

Habitat: Deciduous forests.

Status: *Endangered* throughout. This is a rare southern Appalachian endemic which has a unique, disjunct distribution separated by approximately 240 km (150 mi.).

References: Blomquist, H. L. 1957. A revision of *Hexastylis* of North America. Brittonia 8:255-281.

38. *Hexastylis lewisii* (Fern.) Blomquist & Oosting LEWIS' HEART LEAF



Description: A stemless, rhizomatous herb with evergreen, leathery leaves which are mostly solitary, heart shaped, and rounded at the apex, more-or-less mottled in color. The flower is solitary, under leaves and litter, tubular and bell shaped, with long hairs inside the throat. It is gray brown outside with purple inside and has 5 spreading lobes. Flowering occurs in April and May. (Man. p. 402). Fig. 31, UNC Press.

Distribution: Range -- lower Piedmont and upper Coastal Plain of North Carolina, into SE Virginia.

North Carolina -- Bladen, Cumberland, Duplin, Durham, Granville, Harnett, Lenoir, Nash, Person, Sampson, Vance, and Wake cos.

Habitat: Deciduous, dry, acid woods, pine forests, or low swampy woods.

Status: *Threatened* endemic. This Heart Leaf is fairly widespread in central North Carolina and adjacent Virginia, but uncommon throughout. It is being eliminated by development and other uses of the lands where it occurs.

References: Blomquist, H. L. 1957. A revision of *Hexastylis* of North America. *Brittonia* 8:255-281.

39. *Hexastylis naniflora* Blomquist

DWARF-FLOWERED HEART LEAF
OR DWARF-FLOWERED WILD GINGER

Description: A stemless, rhizomatous, perennial herb with leathery, evergreen, heart-shaped leaves 4 to 6 cm long or wide. The flowers are axillary, solitary, fleshy, firm, and on short stalks, often under leaves and forest litter. The calyx tube is cylindrical or slightly narrowed at the top, and ridged on the inner surface. The anther connective is not extended, and the style extension is merely notched at the apex. Flowering and fruiting occur in April and early May. (Man. p. 400).

Distribution: Range -- North Carolina, into Piedmont of South Carolina.

North Carolina -- upper Piedmont; Cleveland and Lincoln cos.

Habitat: Deciduous, north-slope woods.

Status: *Endangered* endemic. This species occurs in only four counties in the rapidly changing Piedmont crescent, an area undergoing accelerated urbanization.

References: Blomquist, H. L. 1957. A revision of *Hexastylis* of North America. *Brittonia* 8:255-281.

PORTULACACEAE
(Purslane Family)

40. *Portulaca smallii* P. Wilson

SMALL'S PORTULACA



Description: A prostrate, tufted annual, 3 to 10 cm tall. The leaves are simple, succulent, and linear to spatulate. There is a tuft of hairs in the leaf axils. The flowers are terminal, surrounded by hairs and 10 or more leaves. The corolla is pink. There are usually 5 petals, and 8-12 stamens with filiform filaments, and 4 style lobes. The capsule is subglobose, the seeds black and tuberculate. Flowering and fruiting occur June to October.

(Man. p. 434). Fig. 32, UNC Press.

Distribution: Range -- Piedmont of North Carolina; DeKalb Co., Georgia.

North Carolina -- Forsyth, Franklin, Granville, Rowan, and Wake cos.

Habitat: Granitic outcrops.

Status: *Endangered* throughout. This species is a highly localized endemic, known only from North Carolina and Georgia, that is in great danger of extinction due to quarrying of its habitat.

CARYOPHYLLACEAE

(Pink Family)

41. *Arenaria godfreyi* Shinnery

GODFREY'S SANDWORT

Description: A small, glabrous, perennial herb with stems 1 to 4 dm (4 to 15 1/2 in.) long, growing prostrate. The leaves are opposite, simple, and linear. The small flowers are axillary and 5-parted, with white petals. Flowering and fruiting occur from April to June. (Man. p. 443).

Distribution: Range -- North Carolina, South Carolina (Horry Co.), Florida, and Alabama.

North Carolina -- outer Coastal Plain; Craven and Jones cos.

Habitat: Woodland seepage slopes of marl substrates.

Status: *Endangered* throughout. The fact that this plant occurs in such very restricted habitats probably accounts for its rareness.

42. *Arenaria uniflora* (Walter) Muhl.

SINGLE-FLOWERED SANDWORT



Description: A small, glabrous annual with a basal rosette of leaves and an erect stem 2 to 9 cm tall. The small leaves are opposite, simple, and linear or oblong. The flowers are small, white, and 5-parted. Flowering occurs in April and May. (Man. p. 443). Fig. 33, UNC Press.

Distribution: Range -- the Carolinas, Georgia, and Alabama.

North Carolina -- mountains and Piedmont; Anson, Macon, and Rowan cos.

Habitat: Granite outcrops.

Status: *Endangered* throughout. The plants on the flat granite rocks are easily destroyed by quarrying and recreational use.

Remarks: This plant is also known as Rock Witchling and Rock Sandwort.

RANUNCULACEAE
(Buttercup or Crowfoot Family)

43. *Hydrastis canadensis* L.

GOLDENSEAL



Description: An erect, perennial herb from a yellowish rhizome. The plants are 1.5 to 5 dm (5 3/4 to 19 1/2 in.) tall, and usually have a single basal leaf and a pair of petioled stem leaves. The blade is heart shaped, with 3-7 lobes and toothed margins. The flowers are solitary, with pubescent stalk, 3 greenish white sepals and no petals, and numerous stamens and pistils. The fruits become a cluster of red, few-seeded berries. Flowering occurs in April and May, and fruiting in May and June. (Man. p. 455). Fig. 34, NYBG.

Distribution: Range -- widespread from Vermont to E Kentucky; North Carolina. North Carolina -- mountains; Jackson and Madison cos.

Habitat: Rich woods.

Status: *Threatened* throughout, *Exploited*. Duncan (1975) indicates that "localities recorded for this species are very few in the Southeast. It may have been overlooked and possibly has been exterminated from many areas by digging up the root stocks for medical purposes." This species is very rare, yet is still being sought for medicinal uses. It may already be gone from many of the sites for which we have records.

Remarks: This plant is also known as Orangeroot and Tumeric.

References: Duncan, W. H., and L. E. Foote. 1975. Wildflowers of the Southeastern United States. Univ. Georgia Press, Athens, GA.

44. *Ranunculus subcordatus* E. O. Beal

BLADEN BUTTERCUP



Description: A low, stoloniferous, herbaceous perennial with adventitious roots. The leaves are alternate, simple, cordate or subcordate, about 3.5 cm long and 2.5 cm wide, and long petiolate. The upper leaves are smaller and lanceolate. The flowers are small, sepals 5, petals yellow and 4-8, and stamens 7-25. The fruiting heads are globose; achenes 13-38. Flowering and fruiting occur May to July. This species is similar to a South American species, *R. bonariensis*, but has a constant sepal number of 5 and a finely pebbled achenial surface. Fig. 35, Beal (1971).

Distribution: Range -- a North Carolina Coastal Plain endemic; Bladen and Halifax cos.

Habitat: Swamp forests with pH 6.0 to 6.8.

Status: *Endangered* endemic. The Bladen Buttercup is known only from two swamps in two North Carolina counties, and is widely disjunct from its nearest relative in South America. The habitats are subject to draining or impounding.

References: Beal, E. O. 1971. A new species of *Ranunculus* from North Carolina. *Brittonia* 23:266-268.

45. *Thalictrum cooleyi* Ahles

COOLEY'S MEADOWRUE

Description: A weak, erect, dioecious, perennial herb, 4 to 7 dm (15 1/2 to 29 in.) tall. The leaves are divided into small leaflets, and are green above and pale beneath. Sepals of the male flowers are pale yellowish to white, long and early deciduous; those of the female flowers are greenish. Petals are absent, stamens numerous, and the pistil is compound. Flowering occurs in June. (Man. p. 460).

Distribution: Range -- North Carolina endemic, southeastern Coastal Plain; Brunswick, New Hanover, Onslow, and Pender cos.

Habitat: Savannahs.

Status: *Endangered* endemic. This plant occurs in small populations and has a very limited distribution. The savannahs are being transformed into pine plantations or croplands.

References: Ahles, H. E. 1959. *Thalictrum cooleyi* Sp. Nov. Brittonia 11:68-70.

SCHISANDRACEAE
(Schisandra Family)

46. *Schisandra glabra* (Brickell) Rehder

MAGNOLIAVINE



Description: A monoecious, twining, woody vine. The leaves are deciduous, simple, alternate, essentially elliptic, to 15 cm (6 in.) long and 6 cm wide, acuminate, and mostly entire. The flowers are reddish, axillary, and solitary. Male and female perianth segments are reddish, the anthers are imbedded in a reddish disc, and there are 6-12 reddish carpels. The fruit is an aggregate of red berries on a long spike. Flowering occurs May to June, fruiting July to August. (Man. p. 476). Fig. 36, UNC Press.

Distribution: Range -- the Carolinas and Tennessee, to Florida and west to Louisiana and Arkansas.

North Carolina -- Coastal Plain; Martin Co.

Habitat: Mesic woods, climbing on trees like beech, magnolia, and tulip.

Status: *Threatened* throughout. Magnoliavine is a highly localized, unique endemic of the southeastern United States which is fairly abundant in very limited areas where found. It is part of the climax forest, but actually spreads quickly and locally when a disturbance creates an opening in the canopy.

References: Wood, C. E. 1958. The genera of the woody Ranales in the Southeastern United States (Schisandraceae). J. Arnold Arb. 39: 318-320.

LAURACEAE
(Laurel Family)

47. *Lindera melissaefolia* (Walter) Blume SOUTHERN SPICEBUSH
OR PONDBERRY

Description: An aromatic, sparingly branched shrub growing to 1.5 m (5 ft.) tall. The young stems are hairy. The leaves are alternate, simple, firm, hairy, elliptic to ovate and rounded at the base. The small, unisexual flowers are borne in axillary clusters and appear in the spring before the leaves. The perianth is 6 parted, yellow, and glabrous. The staminate flowers have 9 stamens, the pistillate usually have sterile stamens. The fruit is a red drupe. Flowering occurs in March and April, with fruit maturing in August and September. (Man. p. 479).

Distribution: Range -- the Carolinas south to Florida, west to Arkansas and Missouri.

North Carolina -- Coastal Plain; Bladen Co.

Habitat: Swampy depressions, sandy sinks, and pond margins.

Status: *Endangered* throughout. Although known from several states, this species is apparently exceedingly rare and very local. In most of the states listed it is known from only a few localities.

References: Melvin, L. 1954. Notes on some rare plants in North Carolina. J. Elisha Mitchell Sci. Soc. 70:312-314.
Steyermark, J. A. 1949. *Lindera Melissaefolia*. Rhodora 51:153-162.
Tucker, G. E. 1976. A Guide to the Woody Flora of Arkansas. Unpub. PhD dissert., Univ. Arkansas, Fayetteville, AR.
Wood, C. E. 1958. The genera of the woody Ranales in the southeastern United States. J. Arnold Arb. 39:342.

BRASSICACEAE or CRUCIFERAE
(Mustard Family)

48. *Cardamine micranthera* Rollins SMALL-ANTHERED BITTERCRESS

Description: A perennial, erect, slender herb with fibrous roots and one or rarely few simple or branched stems, 2 to 4 dm (7 3/4 to 15 1/2 in.) tall. The basal leaves are lobed, the upper leaves alternate and unlobed. The flowers are subtended by leafy bracts, have 4 white petals, 6 stamens, and small, round anthers. Flowering and fruiting occur in April and May. (Man. p. 508).

Distribution: Range -- North Carolina endemic, upper Piedmont; Forsyth and Stokes cos.

Habitat: Stream banks and moist woods near wooded streams.

Status: *Extinct*. This North Carolina endemic, originally found in Stokes County, was last seen about 35 years ago. It is presumably gone.

SARRACENIACEAE
(Pitcher-plant Family)

49. *Sarracenia rubra* Walter

SWEET PITCHER-PLANT



Description: An herbaceous, rhizomatous, insectivorous perennial with a rosette of hollow, pitcher-like leaves, 1 to 7 dm (4 to 27 in.) tall. There is a narrow wing on one side, the hood is more-or-less erect and 1 to 3 cm wide. The flowers are solitary and sweet scented, with petals that are maroon to red on the outer surface, and red on the inner. Flowering occurs April to June. (Man. p. 512). Fig. 37, McDaniel (1971).

Distribution: Range — the Carolinas, Georgia, Florida, Alabama, and Mississippi.

North Carolina — southern Coastal Plain and southern mountains; Anson, Bladen, Brunswick, Buncombe, Columbus, Cumberland, Duplin, Harnett, Henderson, Hoke, Johnston, Montgomery, Moore, New Hanover, Onslow, Pender, Richmond, Robeson, Scotland, and Wayne cos.

Habitat: Infrequent in shrub bogs and savannahs in the Coastal Plain; rare along streams in the mountains.

Status: *Threatened* throughout, *Exploited*. Although widespread, this insectivorous plant is infrequent but sometimes locally common. It is very colorful, sweet scented, and frequently dug for private gardens or commercial trade. The disjunct populations in the mountains, often recognized as a separate species, *S. jonesii* Wherry, are definitely *Endangered*.

References: McDaniel, S. 1971. The Genus *Sarracenia* (Sarraceniaceae). Bull. Tall Timbers Research Sta. No. 9. Tallahassee, FL.

CRASSULACEAE
(Orpine Family)

50. *Sedum pusillum* Michaux

PUCK'S ORPINE OR STONECROP

Description: A small, winter annual with erect or spreading, ascending branches, 4 to 12 cm tall. The leaves are fleshy, bluish green, overlapping, and cylindric. The flowers are 4-parted, in terminal clusters, and white. Flowering occurs in March and April, fruiting in April and May. (Man. p. 513).

Distribution: Range -- the Carolinas and Georgia.
North Carolina -- Piedmont; Anson and Rutherford cos.

Habitat: In or around vernal pools on granite flat rocks.

Status: *Endangered* throughout. Quarrying and heavy recreational use of the granite flat rocks destroy the limited and unique habitats in which this plant lives.

References: Sherwin, P. A., and R. L. Wilbur. 1971. The contributions of floral anatomy to the generic placement of *Diamorpha cymosa* and *Sedum pusillum*. J. Elisha Mitchell Sci. Soc. 87:103-114.
Clausen, R. T. 1975. *Sedum* of North America north of the Mexican Plateau. Cornell Univ. Press, Ithaca, NY.

51. *Sedum rosea* (L.) Scop.

ROSEROOT

(Including *Sedum rosea* var. *roanense* (Britton) Berger)



Description: A tufted, perennial herb, 1 to 3 dm (4 to 11 3/4 in.) tall, with alternate, crowded, fleshy green leaves. A flat-topped inflorescence terminates each stem, consisting of imperfect flowers (male or female). The sepals are 5 and green, the petals 5 and yellowish to reddish purple. There are 10 stamens, 5 unfused pistils, and 5 fruit follicles per flower. Flowering occurs in July and August, fruiting in August and September. (Man. p. 515). Fig. 38, NYBG.

Distribution: Range -- Appalachian highlands of Pennsylvania, New York, Vermont, and northward into Canada; North Carolina.

North Carolina -- Roan and Grandfather mountains, Avery and Mitchell cos.

Habitat: Rocky cliffs at high elevations, 1,900 m (6,200 ft.), gneiss, with pH of 4.8 and poor to moderate drainage. Associated species are *Carex misera* and *Saxifraga michauxii*.

Reproduction: Accomplished by means of seeds and loose pieces of rhizomes.

Status: *Endangered* disjunct. Roseroot was last counted on Roan Mountain in 1972 and the total population consisted of two plants. This southernmost locality is 960 km (600 mi.) from the nearest naturally occurring populations, and was at various times considered a distinct variety and a separate species.

References: Clausen, R. T. 1975. *Sedum* of North America north of the Mexican Plateau. Cornell Univ. Press, Ithaca, NY.

DIONAEACEAE
(Venus' fly-trap)

52. *Dionaea muscipula* Ellis

VENUS' FLY-TRAP



Description: An insectivorous, perennial herb from a short rhizome. The leaves are basal, and the blade forms a hinged trap about 25 mm (1 in.) long, with bristles on the margins. The traps are active and close suddenly when internal trigger hairs are touched. The petioles are winged and mostly 2 to 7 cm long. The flower stalks are leafless, 1 to 3 dm (4 to 11 3/4 in.) tall. The flowers have 5 white petals. There are about 15 stamens. The fruit is a many seeded capsule. Flowering occurs in May and June, fruiting in June and July. (Man. p. 518). Fig. 39, UNC Press.

Distribution: Range -- North Carolina, South Carolina (Charleston, Georgetown, and Horry cos.).

North Carolina -- southeastern Coastal Plain; Beaufort, Bladen, Brunswick, Carteret, Columbus, Craven, Cumberland, Duplin, Jones, Lenoir, Moore, New Hanover, Onslow, Pamlico, Pender, Robeson, and Sampson cos.

This species is the only member of the family.

Habitat: Wet sandy ditches, savannahs, and open bog margins.

Reproduction: This plant reproduces by seeds and vegetatively, and is easily propagated. It is currently offered for sale throughout the country. Nursery and greenhouse propagation for commercial purposes should be encouraged, and field collection stopped.

Status: *Threatened* endemic, *Exploited*. Although Venus' fly-trap has been reported from 17 North Carolina and 3 South Carolina counties, it is of considerable concern because of the rapid elimination of its habitats by development, the encroachment of forests, and commercial exploitation.

SAXIFRAGACEAE
(Saxifrage Family)

53. *Astilbe crenatiloba* (Britton) Small ROAN FALSE GOAT'S-BEARD
OR ROAN ASTILBE

Description: A coarse, perennial herb. The leaves are basal and on the erect stem, alternate, 2-3 times divided, and the leaflets are crenately toothed or lobed. The flowers are white, minute, and numerous in a large, terminal panicle. The fruit is a small follicle.

Distribution: Range — North Carolina, adjacent Tennessee.
North Carolina — mountains; Mitchell Co.

Habitat: Woods on Roan Mountain.

Status: *Extinct*. This Roan Mountain endemic has not been found since the original collection by N. L. Britton about a hundred years ago. A recent study of herbarium specimens indicates that it was quite distinct from the common False Goats-beard, *A. biternata*, (pers. comm., T. L. Melli-champ).

54. *Saxifraga careyana* Gray

CAREY SAXIFRAGE



Description: A perennial herb with a basal rosette of leaves arising from a rootstock. The leaves are alternate, simple, ovate to slightly obovate, to 14 cm (5 1/2 in.) long and 4 cm wide, coarsely serrate to dentate, and with hairy petioles. The flowers are small, in a panicle, with whitish petals. The stamens are exserted, filaments filiform, and stigmas and styles 2. The capsule is small, and the tiny seeds striate and crested. Flowering and fruiting occur May to June. The species is similar to *Saxifraga caroliniana*, but differs by having shorter fruits, no spots on the petals, and filiform filaments. (Man. p. 529). Fig. 40, UNC Press.

Distribution: Range -- mountains of North Carolina and adjacent Tennessee and Virginia.

North Carolina -- Ashe, Avery, Buncombe, Graham, Henderson, McDowell, Macon, Madison, Mitchell, Rutherford, Swain, Watauga, and Yancey cos.

Habitat: Moist rocks and seepage slopes, usually shaded.

Status: *Threatened* throughout. This is a localized endemic of the southern Appalachians which is not very abundant in its restricted habitat. Some localities are on public land.

References: Lord, L. P. 1961. The genus *Saxifraga* L. in the southern Appalachians. Unpub. PhD dissert., Univ. Tennessee, Knoxville, TN.

55. *Saxifraga caroliniana* Gray

CAROLINA SAXIFRAGE

Description: A perennial herb with a basal rosette of leaves arising from a rootstock. The leaves are alternate, simple, ovate to slightly obovate, to 14 cm (5 1/2 in.) long and 4 cm wide, coarsely serrate to dentate, with hairy petioles. The flowers are small, in a panicle, petals whitish with yellow spots, stamens exserted, filaments clavate, and stigmas and styles 2. The capsule is small, and the seeds striate and crested. Flowering and fruiting occur May to June. The species is similar to *S. careyana*, but differs by having longer fruit, spotted petals, and clavate filaments. (Man. p. 529).

Distribution: Range -- mountains of North Carolina and adjacent Tennessee and Virginia; reported from Kentucky.

North Carolina -- Alleghany, Ashe, Haywood, Jackson, Macon, and Mitchell cos.

Habitat: Moist rocks and seepage slopes, usually shaded.

Status: *Endangered* throughout. The Carolina Saxifrage is a very rare, localized endemic in a restricted habitat of the southern Appalachian Mountains.

References: Lord, L. P. 1961. The genus *Saxifraga* L. in the southern Appalachians. Unpub. PhD dissert., Univ. Tennessee, Knoxville, TN.

ROSACEAE
(Rose Family)

56. *Dalibarda repens* L.

ROBIN-RUN-AWAY



Description: A low, herbaceous perennial with evergreen leaves arising directly from a creeping, slender rhizome, resembling a stemless violet. The leaves have petioles to 6 cm long, with simple, hairy, rounded or heart-shaped blades to 5 cm long. The flowers are of two kinds, some upright, long stalked, and usually sterile, with 5 white petals; others on short, curved stalks, lacking petals, cleistogamous and fertile. Stamens are numerous.

The fruits are hairy, achene-like,

dry drupes. Flowering occurs June to September. (Man. p. 542). Fig. 41, UNC Press.

Distribution: Range -- North Carolina, New Jersey, West Virginia, northward into Canada.

North Carolina -- southwestern mountains; Transylvania Co.

Habitat: Mossy bogs and low, moist woods.

Status: *Endangered* disjunct. The Transylvania County site represents a disjunction of over 480 km (300 mi.) from the nearest locality in West Virginia. Robin-run-away occurs in habitats which are rapidly being eliminated by development, or by the natural encroachment of forest. The open bog habitat will have to be maintained by cutting or burning periodically if this plant is to survive in North Carolina.

Remarks: Robin-run-away is also known as False Violet, Dew Drops, Star-violet, and Dalibarda.

57. *Geum geniculatum* Michaux

BENT AVENS



Description: A perennial herb with basal rosette of leaves. The stem is 5 to 7 dm (19 1/2 to 27 in.) tall, slightly angled, and sparsely to densely hairy. The basal leaves have 3 large terminal divisions, and the stem leaves are 3-lobed or divided into 3 leaflets. The flowers are on stalks from the end of stem branches, with 5 sepals spreading with glandular hairs. There are 5 pinkish, whitish or lavender petals approximately the same length as the sepals, almost truncate at the apex, and gradually narrowed to prominent claws. Stamens and pistils are numerous.

Flowering occurs July to August. (Man. p. 545). Fig. 42, UNC Press.

Distribution: Range -- mountains of North Carolina and eastern Tennessee.

North Carolina -- northwest mountains; Mitchell and Watauga Cos.

Habitat: Wooded slopes and balds at high elevations.

Status: *Endangered* endemic. Bent Aven is locally abundant, but populations are extremely rare. It occurs on public property at Roan Mountain, Mitchell County.

References: Robertson, K. R. 1974. The genera of Rosaceae in the southeastern United States. J. Arnold Arb. 55:384.



58. *Geum radiatum* Gray SPREADING
OR APPALACHIAN AVENS

Description: A perennial herb with basal rosette of leaves. The stem is 2 to 5 dm (8 to 19 1/2 in.) tall, with dense spreading hairs. The basal leaves have a large, kidney-shaped terminal lobe and uneven margins; the stem leaves are considerably smaller than the basal, and rounded to obovate. The flowers are few, terminating stem branches. There are 5 lanceolate sepals, and 5 bright

yellow petals. Stamens and pistils are numerous. Flowering occurs June to August. (Man. p. 545). Fig. 43, UNC Press.

Distribution: Range -- mountains of North Carolina and eastern Tennessee.

North Carolina -- northwest mountains; Ashe, Avery, Mitchell, Stokes, and Watauga cos.

Habitat: Rocky balds at high elevations.

Status: *Endangered* endemic. The species is locally abundant at scattered localities, but the highly restricted habitat makes it extremely susceptible to disturbance. Populations are on public property at Roan Mountain, Mitchell County.

References: Robertson, K. R. 1974. The genera of Rosaceae in the southeastern United States. J. Arnold Arb. 55:385.

FABACEAE or LEGUMINOSAE
(Bean or Pea Family)

59. *Cladrastis lutea* (Michaux f.) K. Koch

YELLOWWOOD



Description: A deciduous tree attaining heights to 25 m (82 ft.), with smooth, gray bark and bright yellow wood when freshly cut. The leaves are alternate, pinnately divided with 5-11 oval or elliptical leaflets 6 to 18 cm long. The flowers are white, pea like, and fragrant, in pendent clusters to 5 dm (19 1/2 in.) long. The fruit is a thin legume. Flowering occurs in April and May and fruiting in July and August. (Man. p. 580). Fig. 44, UNC Press.

Distribution: Range -- southern Indiana and Illinois south through Missouri, Kentucky, North Carolina and Tennessee, to Oklahoma, Arkansas, Alabama, and Georgia.

North Carolina -- mountains; Cherokee, Clay, Graham, Haywood, Macon, Madison, and Swain cos.

Vascular Plants -- Accounts Primary Concern

Habitat: Rich coves and, particularly, limestone soils along river bluffs. Occurs in disturbed areas (early succession) but is maintained in climax forests by stump sprouting.

Reproduction: Seeds are produced at irregular intervals, probably three to four years, and seed production is usually low in most populations.

Status: *Threatened* throughout. Yellowwood is a relict of earlier geological times, with the populations contracting for the past several thousand years. The forestry practice of removing it as a weedy species further threatens its existence. It is exploited for ornamental plantings and for its colorful wood. It occurs on private and public lands in several states.

Remarks: This tree is also known as Gopherwood and Virgilia. The scientific name apparently should now be *Cladrastis kentuckea*.

References: Pittillo, J. D. 1963. Distribution and ecology of *Cladrastis lutea*. Unpub. MS thesis, Univ. Kentucky, Lexington, KY. 33 pages.

_____. 1976. Yellowwood (*Cladrastis lutea* Fabaceae): an example of a nationally threatened species. ASB Bull. 23(2):87. Abstract.
Wilbur, R. L. 1963. The Leguminous Plants of North Carolina. N. C. Agri. Exp. Stat. Tech. Bull. No. 151, Raleigh, NC.

60. *Psoralea macrophylla* Rowlee ex Small

BIGLEAF SCURFPEA
OR BIGLEAF PSORALEA

Description: An erect, perennial, rhizomatous herb growing to 1 m (40 in.) tall. The leaves are alternate, with 3 leaflets each 6 to 8 cm long, heart shaped at the base, and glandular dotted. The flowers are in terminal racemes 2 to 3 dm (8 to 11 3/4 in.) long; each pea-like flower is about 1 cm long and purplish in color. The fruit is a legume. Flowering occurs in summer. (Man. p. 600).

Distribution: Range -- North Carolina mountain endemic; Polk Co.

Habitat: Wooded slopes of Tryon Mountain.

Status: *Extinct*. This is a very distinct, endemic species which was found in 1897 and known only from the original location on Tryon Mountain. It has not been seen since that time.

Reference: Wilbur, R. L. 1963. The Leguminous Plants of North Carolina. N. C. Agri. Exp. Stat. Tech. Bull. No. 151, Raleigh, NC.

ANACARDIACEAE
(Cashew Family)

61. *Rhus michauxii* Sargent

MICHAUX OR FALSE POISON-SUMAC

Description: A dioecious, deciduous, densely hairy shrub, 1.5 to 4 dm (5 3/4 to 15 1/2 in.) tall. The leaves are alternate and once divided, with 9-13 leaflets on an axis which is wingless or very narrowly winged. The leaflets are hairy and toothed on the margin. The small flowers are in a terminal, erect, dense cluster, each 4-5 parted, and are greenish yellow to white. The fruit is red and hairy. Flowering occurs in June. (Man. p. 678).

Distribution: Range -- the Carolinas and Georgia.

North Carolina -- inner Coastal Plain and lower Piedmont; Davie, Durham, Franklin, Hoke, Moore, Orange, Randolph, Robeson, Wake, and Wilson cos.

Habitat: Sandy or rocky, open woods, perhaps associated with basic soils.

Status: *Threatened* throughout. This sumac is fairly widespread, but uncommon and threatened by the loss of available habitats.

AQUIFOLIACEAE
(Holly Family)

62. *Ilex amelanchier* M. A. Curtis

SARVIS HOLLY



Description: A shrub or a small tree, generally less than 1.8 m (6 ft.) tall. The leaves are deciduous, alternate, simple, dull above and veiny and slightly pubescent beneath, 4 to 10 cm long, 1.3 to 4.5 cm wide, and finely and inconspicuously toothed on the margin. The flowers are unisexual and in leaf axils or at leafless nodes below the leaves. The pollen flowers are in stalked clusters of 3-5, the pistillate flowers and fruits solitary. The flowers are 6 to 7 mm across, white, and 4-parted. The fruit is a dull,

red drupe. Flowering occurs in April and May, fruiting in October and November. (Man. p. 682). Fig. 45, UNC Press.

Distribution: Range -- SE Virginia to Georgia and N Florida, west to SE Louisiana in the Coastal Plain.

North Carolina -- Sandhills and southeastern Coastal Plain; Brunswick, Columbus, Harnett, Hoke, Pender, Richmond, Robeson, and Scotland cos.

Habitat: Sandy swamps, wooded stream and river banks, and low floodplains.

Status: *Threatened* throughout. This is a rare shrub throughout its range, and is threatened by drainage of swamps, logging operations, and stream channelization.

CISTACEAE
(Rockrose Family)

63. *Hudsonia montana* Nuttall MOUNTAIN GOLDEN HEATHER
(*Hudsonia ericoides* ssp. *montana* (Nuttall) OR MOUNTAIN HUDSONIA
Nickerson & J. Skog)



Description: A low, spreading, freely branched shrub, not over 3 to 4 dm (11 3/4 to 15 1/2 in.) tall. The leaves are evergreen, alternate, crowded, needle shaped, and 3 to 7 mm long. The flowers are solitary on stalks at the ends of short spur shoots or terminating branches. There are 5 hairy sepals, 5 yellow petals which are twice as long as the sepals, and 5-25 stamens. The ovary is hairy to the base. Flowering occurs in June and July, fruiting in August and September. (Man. p. 718). Fig. 46, UNC Press.

Distribution: Range -- North Carolina mountain endemic; Burke Co.

Habitat: Rock cliffs on high peaks and ridges.

Status: *Endangered* endemic. This very localized species exists on high rock ledges and is quite vulnerable to disturbance and elimination by rock climbers. The population known originally on Table Rock Mountain has been destroyed in the last 20 years by hikers and climbers.

HALORAGACEAE
(Water-milfoil Family)

64. *Myriophyllum laxum* Schuttlew. ex Chapman LOOSE WATERMILFOIL

Description: A perennial, submersed or emersed aquatic herb, with whorled and alternate leaves. The submersed leaves are to 3 cm long, whorled, and each is dissected into 3-7 pairs of linear segments. The small emersed leaves are cleft to entire. The flowers are perfect or imperfect, borne in the axils of the emersed leaves. There are 4 tiny sepals and 4 tiny petals. The fruit is 4-celled and 4-seeded and separating into 1-seeded, very small, rounded mericarps which are minutely warty on the surface. Flowering occurs June to October. (Man. p. 758).

Distribution: Range -- Coastal Plain of the Carolinas, Georgia, and Florida,

North Carolina -- Brunswick and Craven cos.

Habitat: Ponds and sinks.

Status: *Threatened* throughout. This southeastern Coastal Plain endemic may be locally abundant when present. It is often associated with another *Threatened* species, the Dwarf Bladderwort, *Utricularia olivacea*. The pond and sink habitats are disappearing at a rapid rate, and habitat preservation is greatly needed.

ARALIACEAE
(Ginseng Family)

65. *Panax quinquefolium* L. GINSENG



Description: A perennial herb with unbranched stem, 2 to 6 dm (7 3/4 to 23 1/2 in.) long, from a white, fleshy root. The leaves are 1-5 in a single whorl, each with 3-5 leaflets to 15 cm long and 8 cm wide, and toothed on the margin. The flowers are small, with 5 white petals, and clustered in a single umbel at the top of a stalk 2 to 25 cm long. The fruit is a scarlet drupe to 1 cm in diameter. Flowering occurs in May and June, fruiting August to October, (Man. p. 760). Fig. 47, UNC Press.

Distribution: Range -- southeastern United States from N Florida to Louisiana and north into Canada.

North Carolina -- mountains and Piedmont; Ashe, Burke, Durham, Haywood, Henderson, Jackson, Lee, Macon, Madison, Mecklenburg, Mitchell, Moore, Orange, Polk, Swain, Transylvania, and Wake cos.

Habitat: Rich woods of slopes and coves.

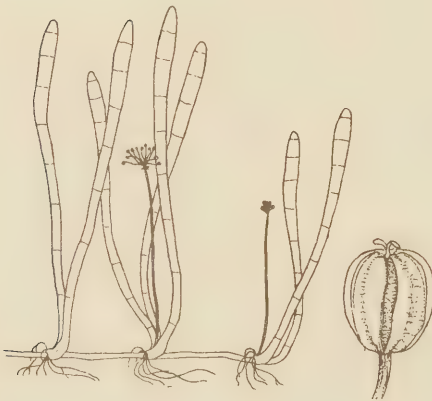
Status: *Threatened* throughout, *Exploited*. This is a widespread plant of sporadic occurrence or locally common. However, it is threatened by extensive exploitation. The root is dug for sale on the crude drug market as a medicinal plant. This is a very old but recently growing business which could lead to the eradication of the species in native habitats unless the plant is cultivated for commercial purposes.

Remarks: Other names for this plant include Sang and American Ginseng.

APIACEAE or UMBELLIFERAE
(Parsly or Carrot Family)

66. *Lilaeopsis carolinensis* Coult. & Rose

CAROLINA LILAEOPSIS



Description: An aquatic, perennial herb with prostrate, submerged stems rooting at the nodes. The leaves are alternate, erect, hollow, septate, cylindrical or flattened, and 7 to 35 cm (2 3/4 to 14 in.) long. The flowers are white and small, shorter than the leaves, and in umbels at the top of a stalk 2 to 5 cm long. Flowering occurs April to June. (Man. p. 783). Fig. 48, UNC Press.

Distribution: Range -- SE Virginia to Florida, Louisiana, and South America.

North Carolina -- outer Coastal Plain; Brunswick, Currituck, and Dare cos.

Habitat: Open mud flats of freshwater marshes and shallow ponds.

Status: *Endangered* throughout. This species is widespread but very infrequent, and occurs in habitats often drained or filled for development.

67. *Ptilimnium fluviatile* (Rose) Mathias

STREAM MOCKBISHOPWEED



Description: An erect or spreading annual, 2 to 5 dm (7 3/4 to 19 1/2 in.) tall. The leaves are hollow, cylindrical, thread like, and to 12 cm long. The small flowers are axillary and terminal in compound clusters. There are 5 sepals with small, sharp teeth on the margins. The petals number 5, are white, rarely pink, and have a narrowly inflexed apex. There are 5 stamens and 2 styles. Flowering occurs in July and August. (Man. p. 784). Fig. 49, UNC Press.

Distribution: Range -- Alabama, north to Carolinas, West Virginia, and Maryland.

North Carolina -- Piedmont; Chatham and Granville cos.

Habitat: Rocky shoals, sandbars, and stream margins.

Status: *Threatened* throughout. Populations of this plant are small and very local. Because it is an annual and occupies dynamic habitats it is very susceptible to disturbance.

References: Easterly, N. W. 1957. A morphological study of *Ptilimnium*. Brittonia 9:136-145.

ERICACEAE
(Heath Family)

68. *Kalmia cuneata* Michaux

WHITE WICKY OR WHITEWICKY KALMIA

Description: A small deciduous shrub to 9 dm (35 in.) tall, erect, and sparsely branched. The leaves are alternate, simple, 2 to 7 cm long, 1.5 to 3 cm wide, light green, cuneate, leathery, and stalked glandular below. The flowers are in lateral bundles of 1-3, clustered near the tips of the stem. There are 5 sepals, which are stalked glandular, and 5 petals, united and cup shaped, greenish white with a red ring near the base, and stalked glandular on the outside. There are 10 stamens, and the anthers fit into small pockets in the petals before pollination. The stigma is capitate and the style long. The fruit is a 5-locular capsule, stalked glandular. Flowering occurs May to June. (Man. p. 804).

Distribution: Range -- southeastern Coastal Plain of North and South Carolina (Darlington Co.).

North Carolina -- Bladen, Cumberland, Hoke, Moore, Pender, Richmond, and Scotland cos.

Habitat: Sandy, peaty soils along open sunny borders of thickets and shrub bogs; pocosin ecotones.

Reproduction: This plant reproduces from rhizomes and seeds.

Status: *Endangered* endemic. White Wicky occurs in small populations and has a very limited distribution. It is highly susceptible to habitat disturbance and natural succession, and occupies a definite successional stage. Management of this stage by cutting or fire is necessary to perpetuate the species.

References: Southall, R. M., and J. W. Hardin. 1974. A taxonomic revision of *Kalmia* (Ericaceae). J. Elisha Mitchell Sci. Soc. 90:1-23.

69. *Rhododendron bakeri* (Lemon & McKay) Hume
(*R. cumberlandense* E. L. Braun)

CUMBERLAND OR
CAMP'S RED AZALEA



Description: A deciduous shrub, 0.6 to 1.5 m (2 to 5 ft.) tall, with stiff hairs on the branches. Flowering occurs after the leaves develop. The leaves are alternate and simple, and crowded on the twig. The flowers are irregular shaped with a long tube, glandless stalks, and are red or deep orange. The fruit is a capsule. Flowering occurs in June and July or later. Fig. 50, NYBG.

Distribution: Range -- mountains of North Carolina, N Georgia, Alabama, and Cumberlands of Tennessee and Kentucky.

North Carolina -- high mountains; Ashe, Macon, and Swain cos.

Habitat: Heath balds, open woods, grassy balds, generally at high elevations.

Status: *Threatened* throughout. The Cumberland Azalea is endemic to the high mountains of the southern Appalachians. It is exploited by nurserymen, plant breeders, and for private gardens, but is protected in the Great Smoky Mountains National Park and some areas of the National Forest.

Remarks: This has been considered a diploid race of the Flame Azalea, *R. calendulaceum*, by some authors and included under that species in the Manual, p. 799. It crosses with this plant to produce the colorful display of hybrid azaleas on Gregory Bald. It is considered a distinct species on the basis of a number of features. In comparison with the Flame Azalea, *R. bakeri* has smaller, red flowers with a thinner tube, and blooms generally two to four weeks later.

References: Galle, F. 1968. Native and some introduced azaleas for southern gardens. Ida Cason Callaway Foundation Booklet No. 2, Pine Mt., GA. 28 pages.

70. *Rhododendron vaseyi* Gray

PINK-SHELL AZALEA



Description: An upright, deciduous shrub mostly to 1 m (40 in.) tall, and rarely to 5 m (15+ ft.). The leaves are elliptic, mostly 3.5 to 12 cm long and 1.5 to 5 cm wide, entire or finely toothed, with petioles 5 to 10 mm long. The inflorescence is 3-15 flowered, appearing before the leaves. The pedicels have stalked glands. The tiny sepals are glandular ciliate, the corolla 2-lipped, pink to rose and with red orange to orange dots. There are 5-7 glabrous stamens, and the pistil is longer than the stamens. The fruit is a capsule bearing

stalked glands. Flowering occurs in May and June and fruiting August to October. (Man. p. 798). Fig. 51, UNC Press.

Distribution: Range -- North Carolina high mountain endemic, reported escaped from cultivation in Massachusetts by Fernald (1950) and Wilson and Rehder (1921); Ashe, Avery, Haywood, Jackson (type locality), Macon, Mitchell, Transylvania, and Watauga cos.

Habitat: Bogs and spruce forests at high elevations.

Reproduction: Seeds.

Status: *Threatened* endemic, *Exploited*. This species is restricted to North Carolina and should be protected from habitat destruction. It is also widely cultivated and offered for sale by many nurseries, which should be encouraged to propagate the species and stop field collecting.

- References: Fernald, M. L. 1950. Gray's Manual of Botany, 8th Ed. Amer. Book Co., Boston, MA.
Wilson, E. H., and A. Rehder. 1921. A Monograph of Azaleas. Univ. Press, Cambridge, MA.

DIAPENSIACEAE
(Diapensia Family)

71. *Pyxidanthera barbulata* Michaux var. *brevifolia* (Wells) Ahles
(*Pyxidanthera brevifolia* Wells) WELLS' OR SANDHILL PYXIE MOSS



Description: A low, creeping, compact, evergreen subshrub. The small leaves are alternate, sessile, and hairy. The flowers are solitary and terminal on short branches, the calyx usually pink, and the corolla white to pinkish. The fruit is a small capsule. Flowering occurs March to April. (Man. p. 818). Fig. 52, UNC Press.

Distribution: Range — Coastal Plain of North and South Carolina (Chesterfield Co.).
North Carolina — Harnett and Moore cos.

Habitat: Xeric sandhills of the Coastal Plain.

Reproduction: Primack and Wyatt (1975) report 74% seed set in the population at the Harnett County type locality, but found the seeds difficult to germinate and an absence of seedlings at the sight. They further state that seed dispersal is poor.

Status: *Endangered* endemic. The type locality has largely been destroyed by development. The plants are exceedingly difficult to transplant or propagate.

Remarks: The taxonomic status of these plants is still open to question. Wells (1929) treated them as a distinct species, while Ahles (1964) considered them a variety. Primack and Wyatt (1975) have concluded that the sandhill plants are the result of clinal variation associated with different environmental parameters. Regardless of how this entity is formally treated, the populations represent an extreme form adapted to very dry sand. They are greatly endangered and may disappear shortly if not protected.

- References: Ahles, H. E. 1964. New combinations for some vascular plants of southeastern United States. J. Elisha Mitchell Sci. Soc. 80: 172-173.
- Primack, R. D., and R. Wyatt. 1975. Variation and taxonomy of *Pyxidanthera* (Diapensiaceae). *Brittonia* 27:115-118.
- Wells, B. W. 1929. A new pyxie from North Carolina. J. Elisha Mitchell Sci. Soc. 44:238-239.

72. *Shortia galacifolia* T. & G.

OCONEE BELLS OR SHORTIA



Description: A rhizomatous, stemless, smooth herb or subshrub with nearly round, coarsely toothed leaves 3 to 8 cm long. The flowers are solitary on a leafless stalk to 18 cm long. There are 5 sepals, barely united at the base, and 10 stamens, 5 long and fertile and 5 short and sterile. The fruit is a small capsule. Flowering occurs in March and April, fruiting in July and August. (Man. p. 818). Fig. 53, UNC Press.

Distribution: Range -- western Carolinas and Rabun Co., Georgia.
North Carolina -- mountains; Burke, McDowell, Macon, Swain, and Transylvania cos.

Habitat: Rich woods and stream banks on the Blue Ridge escarpment from about 270 to 630 m (900 to 2,100 ft.) elevation.

Reproduction: *Shortia* reproduces both by seed and by rhizomes. It is exploited by wildflower enthusiasts, and is cultivated extensively in home and institutional botanical gardens.

Status: *Endangered* endemic. This plant is endemic to the Blue Ridge Mountains, in a habitat imperiled by the damming of mountain rivers and streams. It is also in danger from individuals who remove it from sites not otherwise in jeopardy.

Remarks: This species has an interesting history which has attained the status of legend. Following its discovery it was lost for nearly a century, found again, and is now endangered partly because of its rareness and this history. While visiting the Paris Herbarium in 1839, Asa Gray, a noted American botanist, noticed an unnamed specimen among the collections of the famed French botanist Andre Michaux, who had explored the southern Appalachians. The specimen was collected in 1788 at a site designated as the "high mountains of Carolina". Gray named it *Shortia*

galacifolia in honor of the Kentucky botanist Dr. Charles Short, and the fact that its leaves are somewhat like Galax. Gray and other botanists then organized a searching party in the summer of 1840 which combed the slopes of Mt. Mitchell, Grandfather, Roan, Linville, and other high mountains Michaux was known to have visited. They met only failure, but created wide interest in the lost *Shortia* wherever they went. In the spring of 1877, 17 year old George M. Hyams of Statesville rediscovered the species on the banks of the Catawba River, five miles northeast of Marion, McDowell County. The news spread rapidly, and interest was so high that pressed specimens sold for as much as \$50 each. Dr. Charles S. Sargent of Harvard University took up the search for Michaux's original location, and in 1886 Sargent, F. E. Boynton of Highlands, and others found the plants, just as Michaux had 98 years earlier, in the area of the Horsepasture, Toxaway, and Keowee rivers, Oconee County, South Carolina. Since then several other locations have been found, but the entire range is still limited to a small part of the southern Appalachians. The closest relatives of our eastern North American *Shortia* are species in eastern Asia.

References: Davies, P. A. 1952. Geographical variation in *Shortia galacifolia*. *Rhodora* 54:121-124.

PRIMULACEAE
(Primrose Family)

73. *Lysimachia asperulaefolia* Poiret

ROUGH-LEAF LOOSESTRIFE

Description: An erect, perennial, rhizomatous herb, 3 to 6 dm (11 3/4 to 23 1/2 in.) tall, with glandular stems, particularly near the top. The leaves are in whorls of 3-4, sessile, 2 to 4 cm long and 0.8 to 2 cm wide, and glandular near the base and along the veins but otherwise smooth. The flowers are in racemes, with 5 glandular sepals fused at the base, and 5 petals, fused, yellow, and glandular on both surfaces. There are 5 glandular stamens opposite the petals and united into a short tube. The fruit is a capsule, the seeds light brown. Flowering occurs in May and June, fruiting August to October. (Man. p. 823).

Distribution: Range — Coastal Plain of the Carolinas.
North Carolina — Beaufort, Brunswick, Columbus, Cumberland, Onslow, Pamlico, Pender, Richmond, and Scotland cos.

Habitat: Upland bogs dominated by evergreen shrubs.

Status: *Endangered* endemic. This species is found only in the lower Coastal Plain of the Carolinas, and forms an integral part of the unusual flora of this area.

LAMIACEAE or LABIATAE
(Mint Family)



74. *Synandra hispidula* (Michx.) Baillon

SYNANDRA

Description: An herbaceous winter annual or biennial, with erect, square, hairy stems 2 to 8 dm (7 3/4 to 31 in.) tall. The leaves are opposite, simple, heart shaped, toothed, and about as wide as long. The flowers are solitary in the axil of reduced leaves, irregular shaped, 2-lipped, yellow to whitish, often streaked with purple. The fruit consists of 4 nutlets. Flowering occurs in April and May. (Man. p. 906). Fig. 54, UNC Press.

Distribution: Range -- North Carolina, Tennessee, and Virginia, north into West Virginia, Ohio, Indiana and Illinois.

North Carolina -- mountains; Swain Co.

Habitat: Rich, mesic wooded slopes and stream banks.

Status: *Threatened* throughout. This is a widespread mint, but rare and threatened by the elimination of available habitats.

SCROPHULARIACEAE
(Snapdragon or Figwort Family)

75. *Lindernia saxicola* M. A. Curtis

ROCK FALSE PIMPERNEL

Description: An erect herb with slender, angled stems, sparingly branched, 0.7 to 1.2 dm (2 3/4 to 4 3/4 in.) tall. The small leaves are opposite, simple, narrowly elliptic to oblong, and minutely glandular-dotted. The flowers are axillary and solitary, with 5 green sepals and 5 fused petals which are irregular shaped, and lavender blue or pale blue with 2 yellow hairy ridges in the throat. There are 4 stamens, 2 of which are sterile and partially attached to the yellow ridges in the flower throat. The stigma is 2-lobed. Flowering occurs July to September. (Man. p. 942).

Distribution: Range -- North Carolina mountains and Rabun Co., Georgia.

North Carolina -- Cherokee Co.

Habitat: Rocky shoals, sandbars, and stream margins.

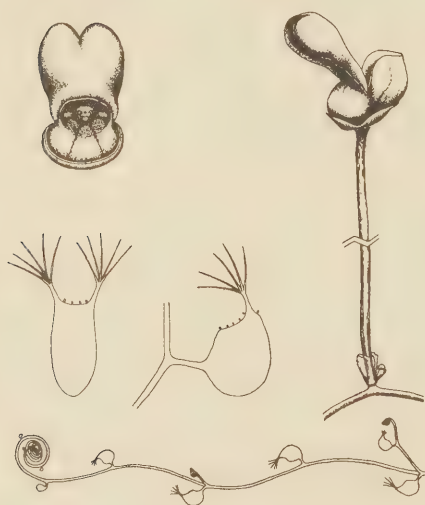
Status: *Extirpated*. This plant is a narrow endemic known only from the type locality in the Hiwassee River, and Tallulah Falls, Georgia. Since there have been no recent collections in North Carolina, it is assumed to be extirpated. Recent reports from Georgia, however, do list it as being extant there.

References: Pennell, F. W. 1935. The Scrophulariaceae of Eastern Temperate North America. Acad. Nat. Sci. Phila. Monogr. 1, Philadelphia, PA. 650 pages.

LENTIBULARIACEAE
(Bladderwort Family)

76. *Utricularia olivacea* Wright ex Grisebach

DWARF BLADDERWORT



Description: A diminutive, floating, herbaceous perennial with capillary, branching stem. The minute leaves are alternate and modified into bladders. The flower is generally solitary and borne on a thickish stalk up to 1 cm long. There are 2 white, petal-like sepals, and 4 petals, united into a lobed upper lip and a pouch-bearing lower lip. There are 2 stamens, connected to the petals, and the stigma is solitary. Flowering occurs September to October. (Man. p. 970).
Fig. 55, Beal & Quay (1968).

Distribution: Range -- New Jersey south along Atlantic Coast to Brazil.

North Carolina -- southeastern Coastal Plain; Brunswick, Carteret, and New Hanover cos.

Habitat: Shallow, acid ponds with pH of 3 to 5.

Status: *Threatened* throughout. The Dwarf Bladderwort has a broad distribution and is locally abundant, but the locations are few and widely scattered. Any change in the delicate habitat could destroy the populations. Several groups occur on federal property at the U. S. Army's Sunny Point Terminal, Brunswick County.

Remarks: This is a carnivorous plant that traps and digests small organisms in the highly specialized, modified leaves (bladders) below the surface of the water. Since its range is limited to the Atlantic Flyway, distribution is thought to be accomplished by birds.

References: Beal, E. O., and T. L. Quay. 1968. A review of *Utricularia olivacea* Wright ex Grisebach (Lentibulariaceae). J. Elisha Mitchell Sci. Soc. 84:462-466.

PLANTAGINACEAE
(Plantain Family)

77. *Plantago cordata* Lam.

HEART-LEAF PLANTAIN

Description: An emersed, aquatic perennial with thick, fleshy roots. The leaves are basal, glabrous, fleshy and dark green, ovate, 1 to 2.5 dm (4 to 9 3/4 in.) long, 0.7 to 1.8 cm wide, with the base rounded to slightly cordate. The small flowers are sessile along the top of a stem 1.7 to 5.5 dm (6 3/4 to 21 1/2 in.) long. The capsule is more than 2.5 mm broad. Flowering occurs in March and April. (Man. p. 975).

Distribution: Range -- Georgia to Louisiana, Kentucky, Virginia, North Carolina, New York to S Ontario, Missouri and Wisconsin.
North Carolina -- Piedmont; Davidson and Stanly cos.

Habitat: Slate-bottom streams, and in swampy woods.

Status: *Endangered* throughout. This species is an infrequent, very local aquatic.

CAPRIFOLIACEAE
(Honeysuckle Family)

78. *Diervilla rivularis* Gattinger

GEORGIA BUSH-HONEYSUCKLE

(*Diervilla sessilifolia* var. *rivularis* (Gattinger) Ahles)

Description: A shrub up to 2 m (6 1/2 ft.) tall, with nearly sessile, deciduous, simple, opposite leaves, 5 to 18 cm long, 2 to 6 cm wide, lacking stipules. The young stems and lower surfaces of the leaves are hairy. There are 5 fused and hairy sepals, 5 fused, irregular petals which are light yellow and turn red on fading, and 5 exerted stamens. The capsule is elongate and abruptly contracted to a slender beak. The seeds are light brown. Flowering occurs June to August, fruiting August to October. (Man. p. 989).

Distribution: Range -- Blue Ridge and Appalachian Mountains of North Carolina, into N Georgia, N Alabama, and E Tennessee.
North Carolina -- Mitchell and Yancey cos.

Habitat: Woodlands and bluffs.

Status: *Threatened* throughout. This species is threatened by its limited distribution and because of the development taking place in the mountains.

References: Hardin, J. W. 1968. *Diervilla* (Caprifoliaceae) of southeastern United States. *Castanea* 33:31-36.

ASTERACEAE or COMPOSITAE
(Composite Family)

79. *Cacalia rugelia* (Shuttl. ex Chapm.) Barkley & Cronq.
(*Senecio rugelia* Gray) RUGEL'S RAGWORT

Description: A tall, coarse, tufted, perennial herb with stems 3 to 5 dm (11 3/4 to 19 1/2 in.) tall, cobwebby below, hairy and glandular above. The basal leaves are alternate, simple, not dissected, 8 to 16 cm long, 5 to 12 cm wide, toothed and hairy; the stem leaves are much smaller. The flowers are in large, compact heads, without rays, enclosed below with green bracts. The color is a dull and dirty white or creamy tan. The nutlets are brown, the pappus white. Flowering occurs June to September. (Man. p. 1037).

Distribution: Range -- high mountains of North Carolina and E Tennessee.

North Carolina -- Haywood, Macon, and Swain cos.

Habitat: At high elevations in forest openings, and in spruce-fir forests.

Status: *Endangered* endemic. This species is restricted to the high mountain peaks, where habitat is endangered by heavy tourist traffic and development. Populations are protected in the Great Smoky Mountains NP.

Remarks: Rugel's Ragwort is also known as Indian-plantain and Mountain Groundsel.

References: Barkley, T. M., and A. Cronquist. 1974. *Cacalia rugelia*: a new combination for a North American Senecionoid. *Rhodora* 76:48-50.

80. *Coreopsis latifolia* Michaux

BROADLEAF COREOPSIS

Description: A glabrous perennial with long rhizomes and erect stems, 7 to 15 dm (27 1/4 to 58 1/2 in.) tall. The leaves are opposite, simple, 10 to 20 cm long, 3.5 to 8.5 cm wide, and coarsely toothed. The flowers are in heads, with disc and ray flowers yellow. Flowering occurs in August and September. (Man. p. 1125).

Distribution: Range — North and South Carolina (Greenville Co.) and Rabun Co., Georgia.

North Carolina — mountains; Buncombe, Henderson, and Polk cos.

Habitat: Rich, moist woods.

Status: *Endangered* endemic. A rare endemic of the lower mountains.

References: Smith, E. B. 1976. A biosystematic survey of *Coreopsis* in eastern United States and Canada. Sida 6:123-215.

81. *Echinacea laevigata* (Boynton & Beadle) Blake

SMOOTH CONEFLOWER

Description: A perennial herb from fleshy roots, with glabrous stems 5 to 10 dm (19 1/2 to 39 in.) tall. The leaves are alternate, simple, lance-ovate to elliptic and smooth, 10 to 15 cm long and 3 to 8 cm wide, and toothed. The flowers are in heads, with the disc flowers purple and the ray flowers deep to pale pink. Flowering occurs between May and July and fruiting June to October. (Man. p. 1110).

Distribution: Range — Piedmont of Alabama, Georgia, the Carolinas, Pennsylvania, and Virginia.

North Carolina — Durham, Montgomery, and Orange cos.

Habitat: Basic or circumneutral soils of meadows, woodlands, and borders.

Reproduction: This showy plant has a relatively low reproductive potential, seldom producing viable seeds.

Status: *Threatened* throughout. The populations of Smooth Coneflower are widely dispersed but usually relatively limited. The areas of its occurrence are being developed. All North Carolina locations are privately owned, but it occurs on National Forest lands in Georgia and South Carolina.

Remarks: This plant is also known as Smooth Echinacea and Purple Coneflower.



82. *Eupatorium resinosum* Torrey ex DC.
RESINOUS JOE-PYE-WEED

Description: An erect, perennial herb, 0.6 to 1.5 m (2 to 5 ft.) tall, with densely hairy stems. The leaves are opposite, sessile, 8 to 12 cm long, 1 to 2.3 cm wide, densely short hairy and resinous dotted beneath, and have toothed margins. The flowering heads usually have 7 flowers, arranged in a flat-topped inflorescence, with densely hairy branches. The involucre bracts are blunt and in several series. The petals are white, and the nutlets have a tuft of white hairs on the top. Flowering and fruiting occur August to October.

(Man. p. 1059). Fig. 56, NYBG.

Distribution: Range -- North Carolina, coastal pine barrens of Delaware and New Jersey.

North Carolina -- Coastal Plain; Bladen, Cumberland, Harnett, and Hoke cos.

Habitat: Lowland and upland bogs often dominated by evergreen shrubs.

Status: *Threatened* disjunct. This species is separated from its nearest populations by over 640 km (400 mi.). It is threatened because of its limited distribution in four counties that form a tight geographical area, and because its habitat is being destroyed as additional land is prepared for agriculture.

83. *Helianthus schweinitzii* T. & G.

SCHWEINITZ' SUNFLOWER



Description: A tuberous rooted perennial with one to several hairy stems to 1.5 m (5 ft.) tall. The leaves are simple, opposite, or alternate above, 6 to 18 cm long, 1 to 2 cm wide, and lanceolate. They are felty below and sand-papery above. The flowers are in heads; disc flowers and rays are yellow. The nutlets are dark brown. Flowering and fruiting occur in September and October. (Man. p. 1113). Fig. 57, Heiser et al. (1970).

Distribution: Range — North and South Carolina (Lexington Co.).

North Carolina — southern Piedmont and Coastal Plain; Cabarrus, Columbus, Mecklenburg, Montgomery, Rowan, Stanly, and Union cos.

Habitat: Woodlands, thickets, and meadows.

Status: *Threatened* endemic. Although it may be locally abundant, this sunflower has a restricted range and populations are likely to decline with habitat modifications. As far as is known it occurs only on private lands, with a possible exception in the Uwharrie National Forest.

Remarks: This species has the most restricted range of any known hexaploid sunflower.

References: Heiser, C. B., Jr., and collaborators. 1969. The . North American sunflowers (*Helianthus*). Mem. Torrey Bot. Club 22:1-218.

84. *Liatris helleri* (Porter) Porter

HELLER'S GAYFEATHER
OR HELLER'S BLAZING STAR

Description: An herbaceous perennial with smooth or hairy, erect stems to 1.5 m (5 ft.) tall. The leaves are alternate, simple, and linear to narrowly elliptic. The tubular lavender flowers are in heads scattered along the stem. The nutlets are blackish, with a pappus 1/2 or less the length of the flower tube. Flowers late July to August and sets seeds September to October. (Man. p. 1050).

Distribution: Range — North Carolina; one population in Alabama. North Carolina — mountains; Avery, Burke, Caldwell, Mitchell, and Watauga cos.

Habitat: Primarily rock ledges but is also seen in rocky woods and meadows.

Status: *Threatened* throughout. The restricted habitat type is the main basis for its limited distribution. It is found on National Forest lands.

85. *Prenanthes roanensis* (Chickering) Chickering ROAN RATTLESNAKEROOT

Description: An erect herb with stems to 12 dm (45 3/4 in.) tall. The leaves are alternate, and either unlobed, 3-lobed, or dissected. The yellow flowers are in small heads, which have purple scales with long purple hairs. The nutlets have a whitish or cream pappus. Flowering and fruiting occur from August to frost. (Man. p. 1020).

Distribution: Range — North Carolina, limited populations in Tennessee and Kentucky.

North Carolina — mountains; Ashe, Avery, Buncombe, Burke, Haywood, McDowell, Mitchell, Swain, Transylvania, Watauga, and Yancey cos.

Habitat: Along road banks, borders, and in woods.

Status: *Threatened* throughout. The species is not abundant in any location although it does occur over a rather large area. It occurs on public lands in all three states.

86. *Rudbeckia heliopsidis* T. & G.

SUN-FACING CONEFLOWER
OR BLACK-EYED SUSAN



Description: A branched perennial herb with smooth or hairy stems to 12 dm (45 3/4 in.) tall. The leaves are alternate, simple, ovate, smooth or rough, and toothed. The flowers are in heads, with disc flowers purplish black and ray flowers yellow and spreading. The nutlets are brown or black, and the chaff is blunt and densely hairy at the apex. Flowering and fruiting occur from July to September. (Man. p. 1108). Fig. 58, UNC Press.

Distribution: Range — Coastal Plain of North Carolina;

Piedmont to Valley and Ridge of South Carolina, Georgia, Alabama, and Virginia.

North Carolina -- Brunswick and Harnett cos.

Habitat: Woodlands, meadows, and low ground.

Status: *Threatened* throughout. The species is widely scattered but only locally common. It is not the common Black-eyed susan.

87. *Senecio millefolium* T. & G.

DIVIDED-LEAF GROUNDSEL
OR DIVIDED-LEAF RAGWORT

Description: An erect, slender, perennial herb, 3 to 7 dm (11 3/4 to 27 1/4 in.) tall, and cobwebby at the base. The leaves are alternate, simple, very finely dissected and mostly basal. The yellow flowers are in heads clustered at the top. The nutlets are with or without white pappus. Flowering and fruiting occur late April to early June. (Man. p. 1035).

Distribution: Range -- southern Appalachians in North Carolina; Pickens and Greenville cos, South Carolina; Rabun Co., Georgia.

North Carolina -- Buncombe, Henderson, Jackson, Macon, and Polk cos.

Habitat: On or near rock outcrops.

Reproduction: Good fruit set is seldom observed for the species.

Status: *Endangered* throughout. This species occurs on National Forest lands as well as private holdings.

Remarks: Some cultivation has been tried, but this species does not do well under cultivated conditions.

88. *Solidago porteri* Small

PORTER'S GOLDENROD

Description: An erect herb with stem 6 to 14 dm (23 1/4 to 54 1/2 in.) tall, glabrous below and slightly hairy above. The leaves are alternate, simple, toothed, and sparsely hairy. The flowers are in heads forming a dense, narrow, terminal panicle. The heads have blunt-tipped involucre bracts, and the flowers are orange yellow, the petals strongly veined. The fruit is a blackish achene. Flowering occurs in summer.

Distribution: Range -- North Carolina mountains; Piedmont of Georgia (Jasper Co.).

North Carolina -- Buncombe and Jackson cos.

Habitat: Dry woods and rock cliffs.

Status: *Extinct*. This narrow endemic was collected on Whiteside Mountain in 1882 and near Asheville in 1899, but has not been found at either locality since. It is also currently unknown from the original locality near Monticello, Georgia. The taxonomic status is somewhat questionable, for it may have represented a more robust and less hairy form of *S. hispida* Muhl.

89. *Solidago pulchra* Small

CAROLINA GOLDENROD

Description: A slender, single-stemmed perennial, 3 to 10 dm (11 3/4 to 39 in.) tall. The basal leaves are oblanceolate to elliptic, petiolate, narrow, and 3 to 12 cm long. The stem leaves are reduced and bract like. The inflorescence is slender, curved at the apex or erect. The flowers are in heads subtended by an involucre. The ray flowers are well developed and pistillate, 3-13 per head, with yellow ray corollas. The disc flowers are perfect, mostly 20-25 per head, with yellow disc corollas. The fruit is a pubescent nutlet. Flowering occurs September to October.

Distribution: Range -- a North Carolina Coastal Plain endemic; Brunswick, Carteret, Pamlico, and Pender cos.

Habitat: Moist, sandy savannahs.

Status: *Endangered* endemic. This species is restricted to the savannahs of the outer Coastal Plain, and habitat preservation and management are needed.

Remarks: The Carolina Goldenrod was included in *S. stricta* Aiton by Ahles (Man. p. 1091), but has recently been treated as a distinct species by Cronquist (1975). According to Cronquist's key, *S. pulchra* can be distinguished from *S. stricta* by the absence of long slender rhizomes and more numerous disc flowers per head, and from *S. gracillima* by the fewer heads (5-25) and more numerous disc flowers per head (20-25 vs 6-16).

References: Cronquist, A. 1975. Asteraceae. In: The Vascular Flora of the Southeastern United States. A. E. Radford (Ed.). In manuscript.

90. *Solidago spithamea* M. A. Curtis

BLUE-RIDGE GOLDENROD

Description: A short, rhizomatous herb with erect stems which are angled and sparsely to densely hairy. The leaves are alternate, simple, elliptic, smooth, toothed, and distributed along the stem and often basal. The heads are 20-30 flowered, in compact clusters, and the flowers are yellow. Flowering occurs July to August. (Man. p. 1088).

Distribution: Range -- North Carolina, and Carter Co., Tennessee.
North Carolina -- Avery, Mitchell, and Watauga cos.

Habitat: Balds and rock crevices in the mountains.

Status: *Endangered* endemic. This goldenrod is distributed in a very narrow range and is not abundant where it occurs. It is found on National Forest and private lands.

91. *Solidago verna* M. A. Curtis ex T. & G. SPRING-FLOWERING GOLDENROD

Description: A perennial herb with short, stout rhizomes. The stems are erect, pubescent, and 4 to 10 dm (15 1/2 to 39 in.) tall. The basal leaves are ovate to elliptic, petiolate, and the blade is toothed. The stem leaves are smaller, and petiolate to sessile. The inflorescence is a panicle or corymb of heads, mostly 25-40 flowered, with glabrous to pubescent involucre. The ray flowers are yellow, mostly 7-12 per head, and the disc flowers are yellow, 14-27 per head. The pappus is of capillary bristles, 3-4 mm long. The small nutlets are pubescent. Flowering occurs from late April to early June. (Man. p. 1097).

Distribution: Range -- Coastal Plain of North and South Carolina (Chesterfield, Darlington, Marlboro cos.).

North Carolina -- Bladen, Brunswick, Columbus, Craven, Cumberland, Harnett, Hoke, Johnston, Jones, Moore, New Hanover, Onslow, Pender, and Sampson cos.

Habitat: Savannas, pocosins, and pine barrens.

Status: *Endangered* endemic. This is a very local species and habitat preservation is needed.

References: Cronquist, A. 1975. Asteraceae. In: The Vascular Flora of the Southeastern United States. A. E. Radford (Ed.). In manuscript.

Vascular Plants -- Peripheral Species

Table 3. *Peripheral*, native and rare species which are endangered (E), threatened (T), extirpated (Ex), or exploited (Ep) in North Carolina. The column headed S is Status.

<u>Species</u>	<u>S</u>	<u>Area of occurrence in N. C.</u>
<i>Lycopodium selago</i>	T	Mountains
<i>Lycopodium porophyllum</i>	T	Southern mountains
<i>Isoetes riparia</i>	T	Coastal Plain
<i>Botrychium oneidense</i>	T	Mountains and Piedmont
<i>Botrychium alabamense</i>	T	Mountains and Piedmont
<i>Botrychium matricariaefolium</i>	E	Mountains
<i>Botrychium lanceolatum</i>	E	Southern mountains
<i>Botrychium lunarioides</i>	T	Southern Piedmont
<i>Ophioglossum crotalophoroides</i>	T	Outer Coastal Plain
<i>Ophioglossum nudicaule</i>	T	Southern Coastal Plain
<i>Ophioglossum petiolatum</i>	E	Outer Coastal Plain
<i>Trichomanes boscianum</i>	E	Southern mountains
<i>Trichomanes petersii</i>	E	Southern mountains
<i>Adiantum capillus-veneris</i>	E	Southeastern Coastal Plain
<i>Cheilanthes alabamensis</i>	E or Ex	Mountains
<i>Woodsia ilvensis</i>	E	Northern mountains
<i>Woodsia scopulina</i>	T	Mountains
<i>Cystopteris bulbifera</i>	T	Mountains
<i>Gymnocarpium dryopteris</i>	E	Northern mountains
<i>Dryopteris spinulosa</i>	T	Southern Piedmont
<i>Dryopteris cristata</i>	T	Mountains and Piedmont
<i>Dryopteris celsa</i>	T	All provinces
<i>Thelypteris phegopteris</i>	E	Southern mountains
<i>Asplenium pinnatifidum</i>	T	Mountains
<i>Asplenium resiliens</i>	T	All provinces
<i>Asplenium ruta-muraria</i>	E	Mountains
<i>Asplenium X bradleyi</i>	E	Southwestern Piedmont
<i>Juniperus communis</i> var. <i>depressa</i>	T	Southern mountains
<i>Taxus canadensis</i>	E	Northern mountains
<i>Typha glauca</i>	T	Outer Coastal Plain
<i>Sparganium chlorocarpum</i>	E	Northern mountains
<i>Halodule beaudettei</i>	T	Outer Coastal Plain
<i>Potamogeton confervoides</i>	T	Southern Coastal Plain
<i>Potamogeton foliosus</i>	T	Mountains and Coastal Plain
<i>Potamogeton natans</i>	Ex	Mountains
<i>Potamogeton amplifolius</i>	T	Coastal Plain
<i>Potamogeton nodosus</i>	T	All provinces
<i>Potamogeton illinoensis</i>	E	Outer Coastal Plain
<i>Sagittaria calycina</i>	T	Piedmont and Coastal Plain
<i>Sagittaria montevidensis</i>	E	Southeastern Coastal Plain
<i>Sagittaria teres</i>	E	Southern Coastal Plain
<i>Tridens carolinianus</i>	T	Southern Coastal Plain
<i>Tridens strictus</i>	T	Southeastern Coastal Plain
<i>Melica nitens</i>	E	Mountains
<i>Glyceria pallida</i>	T	Mountains and Coastal Plain

Table 3. Continued.

<i>Agropyron trachycaulum</i>	E	Southern mountains
<i>Elymus riparius</i>	T	Mountains
<i>Deschampsia caespitosa</i> var. <i>glauca</i>	E	Southern mountains
<i>Sporobolus virginicus</i>	E	Southeastern Coastal Plain
<i>Muhlenbergia sobolifera</i>	T	Mountains
<i>Muhlenbergia glomerata</i>	E	Southern mountains
<i>Agrostis borealis</i>	E	Mountains
<i>Panicum linearifolium</i>	T	Mountains and Piedmont
<i>Panicum neuranthum</i>	E	Outer Coastal Plain
<i>Panicum ovale</i>	E	Southeastern Coastal Plain
<i>Cyperus brevifolius</i>	T	Northern Piedmont
<i>Cyperus lecontei</i>	E	Southeastern Coastal Plain
<i>Cyperus dentatus</i>	E	Southeastern Coastal Plain
<i>Cyperus virens</i>	E	Outer Coastal Plain
<i>Cyperus tetragonus</i>	T	Southeastern Coastal Plain
<i>Eleocharis cellulosa</i>	E	Northeastern Coastal Plain
<i>Eleocharis robbinsii</i>	E	Southeastern Coastal Plain
<i>Eleocharis halophila</i>	E	Outer Coastal Plain
<i>Eleocharis rostellata</i>	T	Outer Coastal Plain
<i>Eleocharis montevidensis</i>	E	Northeastern Coastal Plain
<i>Scirpus cespitosus</i> var. <i>callosus</i>	T	Mountains
<i>Scirpus subterminalis</i>	E	Southwestern Coastal Plain
<i>Scirpus olneyi</i>	E	Outer Coastal Plain
<i>Scirpus acutus</i>	E	Outer Coastal Plain
<i>Scirpus lineatus</i>	E	Northern Piedmont
<i>Scirpus longii</i>	E	Inner Coastal Plain
<i>Hemicarpha micrantha</i>	E	Southeastern Coastal Plain
<i>Rhynchospora tracyi</i>	E	Southeastern Coastal Plain
<i>Rhynchospora breviseta</i>	E	Outer Coastal Plain
<i>Rhynchospora alba</i>	E	Northern mountains
<i>Rhynchospora pleiantha</i>	E	Southeastern Coastal Plain
<i>Rhynchospora stenophylla</i>	E	Southeastern Coastal Plain
<i>Rhynchospora odorata</i>	T	Southeastern Coastal Plain
<i>Carex divisa</i>	E	Southeastern Coastal Plain
<i>Carex arenaria</i>	E	Southeastern Coastal Plain
<i>Carex decomposita</i>	E	Coastal Plain
<i>Carex trisperma</i>	E	Mountains
<i>Carex canescens</i> var. <i>disjuncta</i>	E	Southern Coastal Plain
<i>Carex exilis</i>	E	Southwestern Coastal Plain
<i>Carex projecta</i>	E	All provinces
<i>Carex cristatella</i>	E	Southern mountains
<i>Carex reniformis</i>	E	Inner Coastal Plain
<i>Carex jamesii</i>	E	Inner Coastal Plain
<i>Carex tenax</i>	E	Central Coastal Plain
<i>Carex eburnea</i>	E	Mountains
<i>Carex tetanica</i>	E	Piedmont and Coastal Plain
<i>Carex woodii</i>	E	All provinces
<i>Carex conoidea</i>	E	Mountains and Piedmont
<i>Carex cherokeensis</i>	E	Southern mountains
<i>Carex turgescens</i>	E	Southwestern Coastal Plain

Vascular Plants -- Peripheral Species

Table 3. Continued.

<i>Carex barrattii</i>	E	Inner Coastal Plain
<i>Carex buschawmii</i>	E	Mountains
<i>Carex collinsii</i>	E	All provinces
<i>Carex schweinitzii</i>	E or Ex	Southern mountains
<i>Carex baileyi</i>	T	Mountains
<i>Carex lupuliformis</i>	T	Piedmont and Coastal Plain
<i>Sabal palmetto</i>	E	Southeastern Coastal Plain
<i>Peltandra sagittaeifolia</i>	T	Outer Coastal Plain
<i>Wolffia columbiana</i>	E	Outer Coastal Plain
<i>Wolffia papulifera</i>	E	Piedmont and Coastal Plain
<i>Xyris brevifolia</i>	T	Southeastern Coastal Plain
<i>Xyris elliotii</i>	T	Piedmont and Coastal Plain
<i>Eriocaulon pellucidum</i>	T	Coastal Plain
<i>Eriocaulon septangulare</i>	T	Southern mountains
<i>Lachnocaulon beyrichianum</i>	T	Southeastern Coastal Plain
<i>Commelina caroliniana</i>	E	Southern Coastal Plain
<i>Aneilema nudiflorum</i>	E	Southeastern Coastal Plain
<i>Tradescantia hirsuticaulis</i>	E	Mountains
<i>Heteranthera dubia</i>	E	Northern mountains
<i>Juncus georgianus</i>	T	Piedmont
<i>Trillium discolor</i>	E	Southern mountains
<i>Disporum maculatum</i>	T	Mountains
<i>Streptopus amplexifolius</i>	E	Mountains
<i>Zigadenus glaucus</i>	E	Central mountains
<i>Zigadenus leimanthoides</i>	E	Northern mountains
<i>Schoenolirion croceum</i>	E or Ex	Southwestern Coastal Plain
<i>Lilium philadelphicum</i>	Ep, T	Mountains
<i>Lophiola americana</i>	E	Southeastern Coastal Plain
<i>Cypripedium reginae</i>	E or Ex	Southern mountains
<i>Habenaria orbiculata</i>	Ep, T	Northern mountains
<i>Listera australis</i>	E	Southeastern Coastal Plain
<i>Arethusa bulbosa</i>	E	Southern mountains
<i>Ponthieva racemosa</i>	E	Outer Coastal Plain
<i>Spiranthes longilabris</i>	E	Southeastern Coastal Plain
<i>Spiranthes laciniata</i>	E	Southeastern Coastal Plain
<i>Malaxis spicata</i>	E	Mountains and Coastal Plain
<i>Liparis loeselii</i>	E	Mountains
<i>Epidendrum conopseum</i>	E	Southeastern Coastal Plain
<i>Corallorhiza maculata</i>	T	Mountains
<i>Corallorhiza wisteriana</i>	T	All provinces
<i>Eulophia cristata</i>	E	Southern Coastal Plain
<i>Populus grandidentata</i>	E	Mountains
<i>Carya myristicaeformis</i>	E	Southeastern Coastal Plain
<i>Alnus crispa</i>	T	Mountains
<i>Quercus prinoides</i>	E	Mountains and Piedmont
<i>Quercus ilicifolia</i>	T	Mountains
<i>Planera aquatica</i>	T	Southern Coastal Plain
<i>Humulus lupulus</i>	T	Piedmont
<i>Parietaria floridana</i>	E	Outer Coastal Plain
<i>Polygonella articulata</i>	E	Northern Coastal Plain

Table 3. Continued.

<i>Stellaria aquatica</i>	E	Mountains
<i>Stellaria corei</i>	T	Mountains and Piedmont
<i>Arenaria groenlandica</i>	T	Mountains and Coastal Plain
<i>Silene ovata</i>	T	Southern mountains
<i>Nuphar luteum</i> ssp. <i>sagittifolium</i>	T	Coastal Plain
<i>Aconitum reclinatum</i>	E	Mountains
<i>Caltha palustris</i>	E	Mountains
<i>Isopyrum biternatum</i>	E	Piedmont
<i>Clematis glaucophylla</i>	E	Mountains and Piedmont
<i>Clematis verticillaris</i>	E	Northern mountains
<i>Ranunculus ambigens</i>	E	Piedmont and northern Coastal Plain
<i>Ranunculus hederaceus</i>	E	Northeastern Coastal Plain
<i>Ranunculus flabellaris</i>	E	Northcentral Coastal Plain
<i>Anemone caroliniana</i>	E	Piedmont
<i>Jeffersonia diphylla</i>	E or Ex	Southern mountains
<i>Litsea aestivalis</i>	E	Southeastern Coastal Plain
<i>Adlumia fungosa</i>	E	Southern mountains
<i>Dicentra eximia</i>	E	Mountains
<i>Corydalis sempervirens</i>	T	Mountains and Piedmont
<i>Draba ramosissima</i>	E	Mountains
<i>Draba reptans</i>	E	Southwestern Piedmont
<i>Cardamine angustata</i> var. <i>multifida</i>	E	Piedmont
<i>Cardamine douglassii</i>	E	Piedmont and Coastal Plain
<i>Cardamine rotundifolia</i>	E	Mountains
<i>Arabis lyrata</i>	T	Mountains
<i>Arabis glabra</i>	E	Mountains
<i>Arabis patens</i>	E	Mountains
<i>Arabis laevigata</i> var. <i>burkii</i>	E	Mountains
<i>Warea cuneifolia</i>	E	Inner Coastal Plain
<i>Sedum nevii</i>	Ep, T	Mountains and Piedmont
<i>Drosera filiformis</i>	E	Southern Coastal Plain
<i>Parnassia asarifolia</i>	T	Mountains
<i>Parnassia caroliniana</i>	T	Southern Coastal Plain
<i>Parnassia grandifolia</i>	E	Mountains
<i>Chrysosplenium americanum</i>	E	Mountains
<i>Lepuropetalon spathulatum</i>	E	Southeastern Coastal Plain
<i>Heuchera parviflora</i>	T	Mountains and Piedmont
<i>Heuchera pubescens</i>	E	Mountains and Piedmont
<i>Heuchera longiflora</i> var. <i>aceroides</i>	E	Mountains
<i>Saxifraga pensylvanica</i>	E	Northern mountains
<i>Fothergilla gardenii</i>	T	Southern Coastal Plain
<i>Fothergilla major</i>	E	Mountains and Piedmont
<i>Potentilla tridentata</i>	T	Mountains
<i>Rubus idaeus</i> var. <i>canadensis</i>	T	Mountains
<i>Geum laciniatum</i>	E	Mountains
<i>Geum allepicum</i>	E	Mountains
<i>Geum vernum</i>	E	Piedmont
<i>Filipendula rubra</i>	E	Mountains
<i>Gillenia stipulata</i>	E	Piedmont
<i>Spiraea virginiana</i>	E	Mountains

Vascular Plants -- Peripheral Species

Table 3. Continued.

<i>Crataegus calpodendron</i>	T	Mountains
<i>Crataegus aestivalis</i>	T	Southeastern Coastal Plain
<i>Prunus virginiana</i>	E	Mountains
<i>Baptisia australis</i>	T	Mountains and Piedmont
<i>Amorpha schwerini</i>	T	Piedmont
<i>Amorpha georgiana</i>	E	Southern Coastal Plain
<i>Psoralea onobrychis</i>	E	Mountains
<i>Psoralea lupinellus</i>	T	Southern Coastal Plain
<i>Polygala paucifolia</i>	E	Mountains
<i>Croton monanthogynus</i>	E	Mountains
<i>Sebastiania ligustrina</i>	T	Southern Coastal Plain
<i>Euphorbia purpurea</i>	E	Mountains
<i>Pachysandra procumbens</i>	E	Southern mountains
<i>Euonymus atropurpureus</i>	E	Mountains and Piedmont
<i>Hypericum buckleyi</i>	T	Southern mountains
<i>Hypericum frondosum</i>	E	Mountains
<i>Hypericum adpressum</i>	E	Northern Coastal Plain
<i>Elatine triandra</i>	E	Southern mountains
<i>Hudsonia tomentosa</i>	E	Northeastern Coastal Plain
<i>Helianthemum propinquum</i>	E	Mountains
<i>Helianthemum bicknellii</i>	E	Mountains
<i>Helianthemum rosmarinifolium</i>	T	Southwestern Coastal Plain
<i>Lechea torreyi</i>	E	Southeastern Coastal Plain
<i>Viola tripartita</i>	E	Southern mountains
<i>Opuntia drummondii</i>	T	Outer Coastal Plain
<i>Ammannia teres</i>	E	Outer Coastal Plain
<i>Peplis diandra</i>	E	Piedmont and Coastal Plain
<i>Rhexia aristosa</i>	E	Southern Coastal Plain
<i>Rhexia cubensis</i>	E	Outer Coastal Plain
<i>Rhexia virginica</i> var. <i>purshii</i>	E	Southeastern Coastal Plain
<i>Ludwigia peploides</i> var. <i>glabrescens</i>	T	Coastal Plain
<i>Ludwigia linifolia</i>	E	Southeastern Coastal Plain
<i>Ludwigia alata</i>	E	Outer Coastal Plain
<i>Ludwigia lanceolata</i>	E	Outer Coastal Plain
<i>Ludwigia microcarpa</i>	E	Piedmont and Coastal Plain
<i>Ludwigia repens</i>	E	Outer Coastal Plain
<i>Oenothera perennis</i>	E	All provinces
<i>Epilobium leptophyllum</i>	E	Mountains
<i>Epilobium ciliatum</i>	E	Mountains
<i>Panax trifolium</i>	E	Mountains and Piedmont
<i>Hydrocotyle americana</i>	T	Mountains
<i>Thaspium pinnatifidum</i>	E	Mountains
<i>Ptilimnium costatum</i>	Ex?	Southeastern Coastal Plain
<i>Angelica atropurpurea</i>	E	Southern mountains
<i>Cornus racemosa</i>	E	Northern Piedmont
<i>Monotropsis odorata</i>	T	Mountains and Piedmont
<i>Rhododendrum roseum</i>	E	Mountains
<i>Pieris floribunda</i>	T	Mountains
<i>Vaccinium macrocarpon</i>	E	Mountains and Coastal Plain
<i>Lysimachia fraseri</i>	E	Southern mountains

Table 3. Continued.

<i>Hottonia inflata</i>	T	Northern Coastal Plain
<i>Bumelia tenax</i>	E	Southeastern Coastal Plain
<i>Gelsemium rankinii</i>	E	Southeastern Coastal Plain
<i>Sabatia dodecandra</i> var. <i>kennedyana</i>	E	Southeastern Coastal Plain
<i>Gentiana crinita</i>	E	Mountains
<i>Gentiana alba</i>	E	Northern mountains
<i>Swertia caroliniensis</i>	E	Southern mountains
<i>Menyanthes trifoliata</i>	E	Northern mountains
<i>Asclepias pedicellata</i>	E	Southeastern Coastal Plain
<i>Cynanchum laeve</i>	E	Northern Piedmont and Coastal Plain
<i>Calystegia sericata</i>	E	Southern mountains
<i>Phlox subulata</i>	E	Mountains
<i>Polemonium reptans</i>	E	Northwestern Piedmont
<i>Phacelia ranunculacea</i>	T	Piedmont
<i>Phacelia purshii</i>	E	Mountains
<i>Mertensia virginica</i>	E	Northern Piedmont
<i>Onosmodium molle</i>	E	Piedmont
<i>Lithospermum canescens</i>	E	Northern Piedmont
<i>Callicarpa dichotoma</i>	E	Mountains and Coastal Plain
<i>Scutellaria parvula</i>	E	Piedmont and Inner Coastal Plain
<i>Scutellaria nervosa</i>	E	Northern Piedmont
<i>Scutellaria saxatilis</i>	E	Northern mountains
<i>Meehania cordata</i>	T	Mountains
<i>Macbridea caroliniana</i>	E	Southern Coastal Plain
<i>Salvia azurea</i>	T	Southern Coastal Plain
<i>Lycopus cokeri</i>	E	Southwestern Coastal Plain
<i>Collinsonia verticillata</i>	T	Southwestern Piedmont
<i>Limosella subulata</i>	E	Northeastern Coastal Plain
<i>Bacopa cyclophylla</i>	E	Southeastern Coastal Plain
<i>Veronica americana</i>	T	Northern mountains
<i>Seymeria pectinata</i>	E	Southeastern Coastal Plain
<i>Agalinis maritima</i>	E	Outer Coastal Plain
<i>Agalinis virgata</i>	E	Outer Coastal Plain
<i>Agalinis fasciculata</i>	T	Southern Coastal Plain
<i>Agalinis aphylla</i>	E	Southeastern Coastal Plain
<i>Agalinis tenella</i>	E	Southern Coastal Plain
<i>Schwalbea americana</i>	E	Southern Coastal Plain
<i>Pedicularis lanceolata</i>	E	Southern mountains
<i>Utricularia geminiscapa</i>	E	Outer Coastal Plain
<i>Ruellia humilis</i>	E	Outer Piedmont
<i>Plantago sparsiflora</i>	E	Southeastern Coastal Plain
<i>Diervilla lonicera</i>	E	Mountains
<i>Lonicera canadensis</i>	E	Mountains
<i>Lonicera dioica</i>	T	Mountains
<i>Lonicera flava</i>	E	Southern mountains
<i>Echinocystis lobata</i>	T	Northern mountains
<i>Campanula aparinoides</i>	E	Mountains
<i>Cacalia suaveolens</i>	E	Southern mountains
<i>Senecio pauperculus</i>	E	All provinces
<i>Senecio robbinsii</i>	E	Mountains

Vascular Plants -- Peripheral Species

Table 3. Continued.

<i>Carduus carolinianus</i>	T	Piedmont
<i>Liatris turgida</i>	E	Southwestern Piedmont
<i>Liatris earlei</i>	E	Piedmont
<i>Liatris aspera</i>	E	Mountains
<i>Aster commixtus</i>	T	Southern Piedmont
<i>Aster carolinianus</i>	E	Southern Coastal Plain
<i>Aster laevis</i>	E	Mountains and Piedmont
<i>Solidago radula</i>	E	Southern Piedmont
<i>Solidago squarrosa</i>	E	Mountains
<i>Solidago uliginosa</i>	T	Mountains
<i>Solidago simulans</i>	E	Southern mountains
<i>Chrysoma pauciflosculosa</i>	E	Southwestern Coastal Plain
<i>Heterotheca pilosa</i>	E	Inner Coastal Plain
<i>Polymnia canadensis</i>	T	Mountains
<i>Silphium terebinthenaceum</i>	E	Piedmont
<i>Echinacea purpurea</i>	T	Southern mountains and Piedmont
<i>Echinacea pallida</i>	E	Mountains and southwestern Piedmont
<i>Helianthus glaucophyllus</i>	T	Mountains
<i>Helianthus laevigatus</i>	E	Southwestern Piedmont
<i>Coreopsis gladiata</i>	E	Mountains and Piedmont
<i>Marshallia trinervia</i>	E	Southern mountains
<i>Marshallia grandiflora</i>	E	Mountains and Piedmont
<i>Helenium brevifolium</i>	T	All provinces
<i>Helenium pinnatifidum</i>	E	Southern Piedmont and Coastal Plain

Discussion

Bill Butcher: You say that these species need to be studied, but our previous speaker said that there was only a little time for certain species. Is there time to do an adequate study that you feel is necessary to get the message across to the Legislature?

Hardin: I feel we're going to *have* to study these plants. Certainly we're going to have to start, and just hope there's time. You know, we can get out in the field and study population dynamics, pollination mechanisms, reproductive strategies, and get an ecological atlas in a summer. So, certainly there's time, but we're going to have to get to work now! I don't think that we should throw up our hands and say there's no time so sit back and watch their demise. Sure, I think there's time. Let's start!

Ritchie Bell: If you mean is there time before we go to the Legislature, the answer to that is absolutely not. The answer to the total question of is there time is as you're saying, "yes," but not before we go to the Legislature in another year. We've got to do that immediately.

Hardin: You're right, Ritchie. I think before we go to the Legislature we can, though, get consensus as far as some of our arguments and definitions of status and just what we're talking about in terms of these various categories. What do we mean by "endemic," and what are our arguments for preserving endemics? What are our arguments for preserving "disjuncts?" For example, *Populus grandidentata* is a dominant tree of the Great Lakes area. Do we need to protect it in North Carolina? This is, I think, the kind of thing we can get together on and agree upon before we go to the Legislature.

Bell: Right, but that's not the biological research on the species at all.

Hardin: That's right. Biological research is going to be a longer range study. And, similarly, propagation methods is going to take a longer period of time. But we have to start this research now!

Susan Bondurant: Don't you think that The Nature Conservancy's Heritage Program for inventory in North Carolina will be enough basis to convince our legislators to go on with this legislation that we'll need?

Hardin: I'm afraid I don't know the extent of that study and how well these are to be mapped, and how much information is going to come in terms of the individual populations. What numbers are we talking about in a population of *Kalmia cuneata*? What is the real basis for endangerment? Why do we consider it threatened? Is it doing well? Maybe it's holding its own. I'm not sure whether we will have that kind of information in sufficient amounts from The Nature Conservancy.

Bondurant: I wasn't saying that additional study wasn't needed, I was just saying that, so that we could start the legislative program with a smash, that we could use this in the interim while we're conducting our

own study.

Hardin: Well certainly we'll have to depend on any and all of this information that we can get from all sources.

Ben Sanders: As soon as the Secretary's list of threatened and endangered plants was released, I circulated this list to all the Forest Service personnel in North Carolina, and was immediately overwhelmed with a response that we don't know what these plants are. Can you provide drawings, pictures, common names, and so forth? And I'd like to emphasize this need that you mentioned for good illustrations, and I believe that I might be able to even help with some funding if this is taken as a priority program with the plant group.

Hardin: Great! One thing I mentioned to the Committee, and those at the Workshop yesterday, and I'm convinced of this, is the need for more common names, as you indicated. There are a lot of these little, unknown plants that don't have common names, and I suggested that we make up some. Let's start now, and if all of you will agree that this is the standardized common name then we're well ahead. I think this is important, because the non-taxonomist, the non-professional botanist, is going to want a handle to put on these things rather than, say, *Grammitis nimbata*. That scientific name doesn't mean a thing to most people. So, let's call it the Nimble grammitid fern, or something -- make up some name if necessary.

Sanders: We're influencing about 1.2 million acres of land in the state, and most of the people that are working for us in the capacity of timber markers and as technicians and so forth simply don't know these plants. And I think that it's extremely important that these people be given some working tool other than what I've been able to provide so far.

Hardin: Well, I think we have an excellent opportunity to start getting charts up on bulletin boards of grammar schools, high schools, and colleges. Heck, our college students don't know these plants. I don't know all of them. Dr. Radford is the only one in North Carolina, probably, that knows all these species!

Frank Barick: I'd like to make a couple of points in connection with the preservation of endangered plants, particularly as a contrast with animals. For one thing it seems to me that we need to place a great deal more emphasis on the justification for saving these plants. What values do they have? Because, when you go to the Legislature with a program to save certain plants you are immediately faced with other interests, land owner interests, who are concerned that such programs will impinge on their rights to use their lands. And they immediately become concerned that saving the Venus' fly-trap, for example, will have some drastic impact on whether or not they're able to grow timber. Or to do other things with their lands which, of course, under existing law, they are allowed to do. So, we've got at least these two aspects of this problem that need to be given a great deal of consideration when we approach the Legislature to get them to pass such a law.

Hardin: Thank you, Frank.

Bell: I have a question for the Forest Service people. Would you be interested in possibly some sort of concentrated course of instruction on these plants? We've talked to the State Highway people about getting such a "workshop," I guess, where the people could see the pictures, possibly some of the plants, or pressed materials, and actually learn how to identify them, where they grow, and so on. Pictures are fine, and there are two fine books, I might add, that have quite a few pictures in them that are available, but if some sort of a workshop would help, then we'd be glad to put one on through the Botanical Garden. We're doing this for other groups all the time.

Sanders: Yes, we would be interested in this.

Bell: All right.

Hardin: It might be good, Ritchie, also, if the Garden could -- it's impossible, I know -- grow a lot of these plants together, somewhere in the Garden.

Bell: Well, because of the habitat problems, you can't get them together.

Hardin: Yes, I know it's impossible. But at least have them somewhere in the Botanical Gardens.

Bell: We will try to have a few. We are getting material for this kind of workshop together. We started it with the Highway people last year as an idea, so we'll just open it up to others.

Marc Imlay: How many of these endangered or threatened plants are in the New River system and in the Lake Waccamaw area?

Hardin: I'm not sure. Dr. Radford, do you have an answer for that?

Al Radford: No, I don't. Do you mean in the directly aquatic system?

Imlay: The basins.

Radford: Even in the basin itself, the answer, I'm afraid, is zero.

Hardin: Even in the New River, along the slopes, and in the watershed?

Imlay: Not the aquatics, but the terrestrials.

Radford: Well, on the terrestrials, I'm afraid the answer is still zero. Unless you want to go clear to the top of Mount Jefferson and places like that.

Hardin: Well, I'd raise that to one. Ginseng is in that area, but that's the only one I can think of in the New River area.

Bell: You have a red circle up in Ashe County, though, and isn't that New River drainage?

Vascular Plants -- Discussion

Hardin: If you go on up into the Long Hope Creek area, yes. We do get quite a few of them.

Radford: To me it's a matter of definition . . . the top of Rough Mountain, the top of Mount Jefferson, the top of Phoenix. That's stretching the thing from a legislative standpoint.

Freshwater and Terrestrial Mollusks

by
Samuel L. H. Fuller

Introduction

A total of 28 species of North Carolina non-marine mollusks is of concern to this Committee. They fall into three broad groups: (1) fresh-water mussels (class Bivalvia, family Unionidae, 17 species); (2) fresh-water snails (class Gastropoda, subclass Prosobranchia, order Mesogastropoda, 3 families, 3 species; subclass Pulmonata, order Basommatophora, 1 family, 2 species); and (3) land snails (subclass Pulmonata, order Stylommatophora, 2 families, 6 species).

Study of this fauna begins conveniently with Dawley's (1965) checklist of fresh-water mollusks of North Carolina and Hubricht's (1970) checklist of terrestrial snails of the state. There is a checklist of estuarine species (Wolfe and Wolfe 1970), but none of these was ascertained by this Committee to be in jeopardy. Marine mollusks are considered elsewhere in this volume. Dawley's list is taxonomically somewhat uncritical, thus partially redundant, and includes 100 or so taxa. Recent additions to our knowledge of the North Carolina fauna, however, probably ensure that her original total was nearly correct. Hubricht's list is more current and precise. His total of about 150 taxa is probably a good approximation of the number of land snail forms that will eventually be revealed in the state. In these numerical terms, the non-marine mollusk fauna of North Carolina can be considered rather well known, but this is hardly true in biological terms. For example, although we have listed nine entities as *Endangered*, we have eight as of *Undetermined* status. Thus, not nearly enough is known about this fauna for the purposes of this Symposium or for other purposes. Nevertheless, using the figures given above, we can state unequivocally that about a tenth of the fresh-water and terrestrial mollusks of North Carolina is in one degree or another of jeopardy. This estimate is unlikely to change for the better in the foreseeable future, despite the fact that changes in individual species' classifications are inevitable as a consequence of improved information.

Roughly 10% of the fauna in danger -- this is a sad indictment of our activities. The situation is particularly bad for one of the groups, the fresh-water mussels. Their larvae (the glochidia) must pass a brief period as parasites on a vertebrate host, usually a fish, immediately after discharge from the female. Only a limited number of hosts is physiologically appropriate to a given species of mussel. Disruption of the ichthyofauna can therefore lead to profound changes, usually extirpations, in the mussel fauna. In addition, most mussels are unusually sensitive to the varieties of adversity that affect other fresh-water mollusks. In view of this multiple vulnerability to environmental disturbance, it is not surprising that 17 species and/or populations of mussels are of concern to this Committee. The correct number of mussel species in North Carolina is uncertain, but these 17 are likely a majority.

Other types of disturbance include point-source pollutants like municipal, industrial, and agrarian effluents, and non-point-source effects, such as sheet erosion and biocides. These phenomena are becoming

increasingly well known in the Carolinas (see Hendrickson et al. 1976). Less familiar problems include poor road maintenance, especially of rural roads, and forestry practices. Many of these adversities promote stream sedimentation, while others create toxic effects. All have a deleterious impact on fresh-water mollusks of all kinds, as well as on other aquatic organisms.

Land snails, too, can be affected by many of these factors, especially toxicity. The chief threat to terrestrial species considered in this report, however, is habitat disruption, including deforestation and road cuts. No matter how well intended, in the name of opening additional lands to public recreation, the present and potential activities of state and federal park services threaten, possibly endanger, and may even have already destroyed some of the snails considered below. The increasing abuses of public lands through logging, strip mining, and similar activities represent an added danger, though specific threats of this kind to North Carolina species are not known to us at this time.

Solutions to these problems require both legal and scientific approaches. Local, state, and federal environmental regulations must be updated and strengthened, and reflect increased sensitivity to scientific findings. In the meantime, the existing body of environmental law, which is considerable, must be assiduously enforced. At present this is not being done in very many places. There is some measure of irresponsibility in legislative bodies and the private sector, but just as important are public apathy and ignorance of the facts. These provide a fertile substrate for more conspicuous evils. Because apathy is often at least partially dispelled by knowledge, a Symposium such as this has special timeliness and value, both among scientists (no strangers to ignorance) and non-scientists alike.

In the context of rare, threatened, and endangered biota, a statewide program of public education is needed in North Carolina, and such efforts could pioneer in the nation as a whole. Hunters, fishermen, game wardens, park rangers, public officials, and other non-specialists should be able to distinguish and help protect jeopardized species. Although there are exceptions, most of the mollusks and other organisms of concern to this Symposium are rather easily identified. Therefore, such readily available and understandable literature on the subject as simple field guides is practicable as well as imperative.

We feel that, although the immediately foregoing remarks are justified, such remedies would be initially weakened by a "shotgun" approach. Attention must first be focused on the more crucial target areas of concern. These areas may be defined geographically, or ecologically, or both. The Committee has identified several such areas:

(1) Only a few North Carolina land snails are believed to be in jeopardy. With the exception of *Triodopsis soelneri*, the Waccamaw Helix of the Waccamaw basin and environs, these are montane species dwelling in the western counties. Some are threatened by road construction, park activities, and the like. Their populations must be "roped off" or otherwise segregated from human contact through a program akin to the traditional "bird sanctuary" approach.

(2) The Tar River of the Pamlico basin supports an undescribed species of *Canthytia*, the Tar River Spiny Mussel, and a rich fauna of other fresh-water mussel species. Every effort must be bent to preserve this river from sedimentation, chemical effluents, sewage, and other pollutants, and

channel modifications. Fortunately, there appears to be no impoundment declared for the Tar, although limited "clearing and snagging" projects were completed in 1938, 1942, and 1946 (USACE 1975). Any attempt to renew such activities must be discouraged because of their effect on fish habitats and, as discussed above, the well being of the mussel fauna.

Editor's Note: Since this chapter was completed Rowland M. Shelley has provided the following comments: "Three major impoundments have been proposed for the Tar system, two of which, Spring Hope and Grey Rock, are on the Tar River itself. The other, White Oak, is on Fishing Creek, a major tributary. Moreover, Spring Hope is in that part of the Tar River where *Canthyria* occurs. There may be additional, smaller impoundments planned for this system as well. Also, in the past several years a municipal water supply weir was built across the Tar River in an area of Nash County where *Canthyria* occurs, creating a large lake. The structure could have significant impact on this species, and on *Elliptio lanceolata*."

(3) The Waccamaw basin in southeastern North Carolina and northeastern South Carolina supports more unique non-marine mollusks than any other locale in the state. The mussel fauna is especially notable (see Fuller et al. 1976). Lake Waccamaw itself, at the head of the basin in Columbus County, contains several endemic species and/or populations. The Waccamaw River below the lake is almost as interesting, but in Horry County, South Carolina, it becomes synonymous with the Intracoastal Waterway, and below the confluence this river is almost a molluscan desert (Fuller and Inlay 1976). Lake Waccamaw appears to have suffered little or no damage as a result of a narrow ring of human habitation on its banks, but intensive land development beyond that ring is afoot. If poorly managed, this development would be attended by the usual problems of sediment from construction and road building, organic enrichment from sewage, and others. This could drastically affect the Lake in a few months or years. From the molluscan point of view, protection of Lake Waccamaw is the single most important goal of conservation in the state. The Lake offers North Carolinians a unique opportunity to combine mollusk studies, experimental biology, public education, and ecological research, with judicious human habitation and recreation. Probably the most significant immediate step is stabilization of the shoreline, most of whose original vegetation, especially the tree cover, has long since disappeared. Ever a special case, the Waccamaw basin poses the interesting necessity of vigorous co-operation with neighboring South Carolina if it is to be preserved above the Intracoastal Waterway.

Achievement of conservation of these three "target areas" is the business of the general public, their political representatives, and state agencies, as much as it is a concern of biologists. In the meantime, however, scientists must endeavor to advance our knowledge of at least the 28 mollusks that are of concern in this report. Several kinds of information are of paramount importance. *Helisoma magnificum*, the Cape Fear Ramshorn, and *Taphius eucosmius*, the Greenfield Ramshorn, have been listed here as *Threatened* and presumed *Extinct*, respectively. Perhaps both are gone, but this must be verified or denied through careful search. Similarly, the correct ecological and geographic ranges of all other species must be ascertained. Only then are final decisions on their status warranted, and only then can thorough research into their respective biologies be conducted. For all species of concern, numerous kinds of

knowledge are essential: more and less favored habitats, reproductive season and capability, juvenile and adult mortality, predators, food-stuffs, resistance to physical and chemical factors, and so forth. The list seems endless, but a start must immediately be made. Once again, fresh-water mussels, the group most in jeopardy, offer special problems. Knowledge of the identity of every glochidial host for each mussel species is absolutely necessary, and this calls for the most thoughtful cooperation between ichthyologists and malacologists in a common research enterprise. Essential to all these endeavors is statewide support, be it in the form of financial aid or the neighborly sharing of information by the individual citizen.

One of the potential (and probable) weaknesses of this document is the matter of species deservedly of concern that have been inadvertently or otherwise omitted. Whereas we feel justified in the belief that coverage of the land snails has been thorough, we are not nearly so confident of our treatment of the aquatic fauna. A case in point is the snail family Hydrobiidae. New forms are still being discovered and described almost every year. Many of these species are restricted to springs and other ecologically vulnerable habitats (see *Federal Register* 1976, 41: 17742-17747). It is likely that much of our American hydrobiid fauna was eliminated before we even had the chance to discover it, and this has probably happened in North Carolina. In any case, there are surely more undiscovered and undescribed hydrobiid species in the state than the *Endangered* Waccamaw Snail, discussed below. The fresh-water mussels of the Carolinas are certainly better known than the Hydrobiidae, but include animals that are very inadequately understood. For instance, *Lasmigona subviridis* (Conrad), the Green Floater, should perhaps have been treated among the accounts below. This species ranges widely in the Atlantic drainage of the Carolinas and Virginia, but is infrequently encountered. On the other hand, it is often locally abundant, and has a high degree of tolerance of sedimentation. Therefore, we chose to exclude it from our listings, which may have been a mistake.

The value of our molluscan faunas has never been very widely appreciated. Relevant knowledge concerning the impact on an ecosystem caused by the elimination of one or more species is in its infancy. Already, however, the topic is a large one. Much more is understood about some organisms than about others, and the former obviously better exemplify ecosystematic interrelationships. Of the three broad groups (land snails, aquatic snails, and fresh-water mussels) of concern, mussels best illustrate the present "state of the art". But, both aquatic and terrestrial snails have at least equally important roles in the food web, as nourishment for such invertebrates as leeches, beetles, and other snails, and vertebrates like birds and fishes. These relationships are particularly well documented in the case of fishes and aquatic snails (Baker 1916), and Harman (1974) considered them at length, with emphasis on the disturbed environment. Elimination of a species has an unhealthy effect on the variety, complexity, and ecological resilience of its food web. Thus, the loss of so much as a single kind of snail has adverse consequences, however subtle and removed, for the associated ecosystem and is to be avoided. Extinction means, also, that the potential, immediate, and practical advantages of the fallen are forever lost to man. Such advantages may range from research and actual healing in human medicine, through the advancement of more abstract

knowledge that, seemingly impractical at first, is the foundation of the sort of progress that truly benefits the human species.

Fresh-water mussels share these rather erudite values, but offer a number of practical advantages as well. Certain of these are unique among animal attributes in at least some respects. Together they strongly support the claim that mussels are the most important non-insect group of aquatic macroinvertebrates. First, they are extremely biomassive under optimal circumstances. This point quantitatively underscores the significance of the following qualitative points. Second, as filter-feeders, mussels ingest and commonly digest large quantities of micro-organisms and more or less inert organic material. Figuratively stated, they are natural "vacuum cleaners". Third, mussels accumulate numerous chemical species at concentrations that are readily measurable, whereas background levels are commonly not. Such chemicals include potassium and its compounds, which are common ingredients of wood-products industrial discharges. Paper and pulp mills abound in the Carolinas, and evidence is gradually gathering that this element is toxic to a variety of aquatic animals (M. J. Imlay, pers. comm.). More specifically, potassium at levels as low as 4 ppm can be lethal to fresh-water mussels (Imlay 1973). These remarks emphasize yet another potential if subtle killer of Carolinian wildlife, and demonstrate how valuable mussels can be as monitors of water quality, through bioassay or their absence. Fourth, many mussel species, as shown in the individual accounts which follow, are sensitive monitors of physical habitat disturbances. Fifth is the essential symbiotic relationship between mussels and fishes, already outlined. The important point here is that this relationship may have advantages for host as well as parasite. Wilson (1916) expressed the belief that glochidiosis conferred upon the host(s) an immunity to infection by caligoid copepods known as Anchor Worms, an especially destructive and occasionally epidemic group of fish parasites. Wilson's point was disputed in a geographically and biotically parochial study by Tedla and Fernando (1969), but should he be proven correct, a crucial value of mussels to fish would be established.

These points, plus mussel symbioses with other groups of organisms and their roles in the food web, were additionally discussed by Fuller (1974c). Possibly the most important of such relationships today involves mussels and an introduced bivalve competitor from southeastern Asia, the so-called "Chinese Clam," *Corbicula manilensis* (Philippi). This form is rather closely related to our native fingernail, pea, and pill clams of the family Sphaeriidae (Burch 1972, 1975a). After 30 years as a scourge of the macrobenthos in the Pacific and Gulf drainages, as well as in the Mississippi basin, *C. manilensis* was detected in the Atlantic drainage several years ago. Except in Lake Waccamaw (Fuller and Imlay 1976), this exotic remains undiscovered in North Carolina, but it currently ranges from the Altamaha River basin of Georgia north into the Delaware basin in Pennsylvania and New Jersey¹. Gardner et al. (1976) reviewed the relevant facts and references and told a grim tale of the adverse impact of the Chinese Clam on the naiad fauna of the Altamaha basin. Many of these fresh-water mussels, as the Gardner group correctly reckoned, are endemic to this basin and *Endangered* on a nationwide and global basis. This point of view had been corroborated by Heard (1975), who related, also, his suspicion that *Corbicula* has been the chief factor in the reduction and/or extinction of certain mussels in the eastern Gulf drainage. It seems that no one knows why this pollutant is so devastating to Nearctic

¹ See page 194.

fresh-water mussels. Is *Corbicula* a superior competitor for benthic space on waterway floors? Does it compete selectively for planktonic food? Do the larvae, allegedly solely planktonic, out-compete mussel glochidia for fish hosts? Do adult *Corbicula* devour unionid larvae and/or newly post-larval juvenile mussels? How is this exotic distributed from river basin to river basin? Why has it no apparent effect on aquatic snails? These questions remain unanswered. This must change, for the Chinese Clam suddenly looms as the most effective danger to native unionids in the Atlantic drainage. Fuller and Inlay (1976) suggested that it is most successful where man has already influenced waterways, but the full answer to its depredations remains obscure. Prior to the excellent account by Gardner et al. (1976), the best record of the *Corbicula* story was Sinclair's (1971). Many articles on this species appear in *The Nautilus* (published by the Delaware Museum of Natural History, Greenville), and the interested reader should be aware, also, of the *Corbicula Newsletter* (published by the Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee).

As indicated by the last question posed above, *Corbicula manilensis* does not appear to jeopardize indigenous fresh-water gastropods. However, such snails, and especially rock-dwelling animals like the Pleuroceridae, are threatened by another exotic, the introduced Eurasian snail, *Bythinia tentaculata* (Linnaeus), the Faucet Snail (Emerson and Jacobson 1976). Harman (1974) reviewed this matter, and it appears that *B. tentaculata* is able to out-compete pleurocerid snails only in habitats already disturbed by man. This viewpoint is in harmony with recent evidence (Fuller and Inlay 1976) that *Corbicula manilensis* competes rather poorly with fresh-water mussels in soft-bottom Atlantic drainage streams, such as those on the Coastal Plain of North Carolina, that have not already been disturbed by man. Thus, it appears that exotic organisms probably compete less successfully with native benthos in more natural aquatic habitats. In the Atlantic drainage of the United States, *Bythinia* apparently occurs no farther south than the Potomac River basin in Maryland and Virginia (Krueger 1975), and, as noted above, *Corbicula* ranges widely in this drainage, but is not known to have been recorded widely in North Carolina. The Tarheel State is fortunate that neither of these "immigrants" yet has a firm foothold in the state, but residents are warned that either could pose a very serious threat to native organisms. The appearance and spread of these mollusks is something that could be reported by untrained observers with results of the greatest value. Recognition of the Chinese Clam was considered above. The Faucet Snail may be identified with the aid of works by Emerson and Jacobson (1976), Harman and Berg (1971), and Robertson and Blakeslee (1948).

In order to facilitate communication among users of this volume, including scientists unfamiliar with mollusks, we have provided common names for the 28 species of concern. The goal has been to have the names brief, appropriate, vivid, and consistent with the small body of relevant tradition. A few examples are worth mentioning. Members of the fresh-water mussel genus *Anodonta* are notable for their ability to survive sedimentation because of their lightly built, buoyant shells. Accordingly, they have long been known as "Floaters" in the Mississippi basin and the Gulf drainage, where mussels are more familiar to the general public, through their nearly century-old commercial harvest, than they are in the Atlantic drainage. We have applied the name Floater, suitably qualified for each species, to all

Anodonta, as well as to all *Alasmidonta*, a morphologically, ecologically, and phylogenetically allied genus. Similarly, members of *Lampsilis* and related mussel genera are called "Muckets" in the Interior basin, and the same course is adopted here. On the other hand, the goal of brevity, at least, has not always been achieved, as in "Tar River Spiny Mussel," but, though cumbersome, this name is certainly appropriate.

These names are offered for the convenience of users of this report, and it is not imagined that our creations will stand forever. They may, however, serve as an added stimulus for a movement toward standardization of Nearctic non-marine molluscan names, which is badly needed. Our indiscriminate use of the European "Helix" for almost all land snails is one example of a weakness in our present approach and should eventually be revised in favor of a greater variety of vernacular names.

There are no standard eclectic references to the taxonomy and other aspects of the biology of non-marine mollusks of North Carolina. There are some excellent sources of more limited scope, mentioned below, but none of these is entirely up to date, as will be clear from the individual species accounts. Pilsbry's (1939, 1940, 1946, 1948) monograph on the land snails of North America north of Mexico is the reference of its kind and as valuable in North Carolina as elsewhere. Also of great value for the state are Hubricht's (1970) checklist, Burch's (1962) field guide, and the latter's (1969) biogeography of Appalachian land snails. The standard introduction to fresh-water mussels of the Atlantic drainage, including North Carolina, is Johnson's (1970) treatment. Burch's (1973, 1975b) manuals are superior in certain respects, and the present account by this Group Committee adds novel information to knowledge of mussels in the state. Standard references on the fresh-water snails that are of concern here are the works of Baker (1945), Bartsch (1908), Clench and Turner (1955), Goodrich (1942), Thompson (1968), and Tryon (1873). In general, though, the aquatic gastropods of North Carolina are poorly known.

These books and papers deal primarily with species and are of little avail to the uninitiate, who must first identify an unknown organism through the higher taxonomic ranks before hoping to ascertain a specific determination. For students of North Carolina non-marine Mollusca, this problem is resolved by recourse to one or more of several works of broad systematic scope, including Clarke (1973), Clench (1959), Emerson and Jacobson (1976), Harman and Berg (1971), Heard (1968), Pennak (1953), and Walker (1918). Those interested in the further study of North Carolina mollusks may be aided by the following works: Baker (1911), Basch (1963), Burch (1972, 1975a), Clench and Fuller (1965), Fuller (1974c), Harman (1974), Herrington (1962), Pilsbry (1934), Te (1975), van der Schalie (1965), and Walter (1956).

There can be no doubt that appreciation of our mollusks of concern would have been facilitated by illustrations more numerous than those provided. Nevertheless, in the interests of space and cost, visual aids have been restricted to novelties of form and concept that have not already and adequately been figured elsewhere. References to other published illustrations are given in the species accounts as needed. It must be conceded that restriction of illustrations has been, in effect and in part, a trade-off in favor of more plentiful bibliographic references. In a work of this type, a learning experience for all concerned, these are here interpreted as of greater value to the student than would be additional pictures.

The photographs that adorn certain of the accounts are the work of Daniel J. Bereza, a member of the Committee, and Jerry Harasewych. D. J. Bereza and James D. Williams aided me critically in the selection of many of the vernacular names herein employed. Further, I have profited by written submissions from other members of the Committee. William J. Clench provided most of the information concerning *Spirodon dilatatum*, the Kanawha River Snail, in North Carolina and elsewhere. Leslie R. Hubricht, G. Alan Solem, and especially F. Wayne Grimm, provided or indicated most of the information about land snails. Locality data for numerous species in the state were supplied by Harriet H. Riggs and Rowland M. Shelley. George A. Te sent copious notes regarding the ecological and taxonomic status of the fresh-water snail genus *Physa* in North Carolina, but (thankfully!) no members of this genus, whose resistance to environmental disturbance is notorious, were accorded any jeopardy status by the Committee. Previously unpublished data that were contributed by others are acknowledged here or in the species accounts and should henceforth be cited accordingly (e.g., "Grimm in Fuller (1977)"). In addition, numerous, courageous oral reports by Committee members influenced our deliberations. Finally, decisions about inclusion and status of the 28 species of concern were the responsibility of only those Committee members who were actually able to attend the Symposium. However, as Chairman, and in the light of subsequent information, I have been so bold as to adjust, only slightly and in a few cases, the status of a given species as determined by Committeemen present at the Symposium. In making such decisions and in acquiring new data of various kinds, I have been aided by several persons not actually on this Committee, including Mary G. Curry, Dwight W. Taylor, Ruth D. Turner, Malcolm F. Vidrine, and Kirk E. Wright.

I have taken the execution of this account solely upon myself. Fortunately, the initial manuscript profited from critical readings by selected Committee participants -- Bereza, Grimm, Imlay, Shelley, and Williams. Clearly, any credit that accrues to this narrative must be widely shared, while discredit falls to me alone. Support for various aspects of this report was provided by National Science Foundation Grant GB-40064, the Pew Foundation, the Department of Limnology at the Academy of Natural Sciences of Philadelphia, the Fish and Wildlife Service of the U. S. Department of the Interior, and dozens of persons who gave more of their "spare" time than they could readily afford.

Finally, the most important acknowledgement: profound gratitude goes to my wife, Micki, and children, Sammy and Rebecca, who suffered, not gladly but more or less quietly, the theft from them of the scores of hours required for the preparation of this document, on the dozens of evenings stretching through the many months.

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Freshwater and Terrestrial Mollusks -- Introduction

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Freshwater and Terrestrial Mollusks -- Species List

Species List

Species	Status
Gastropoda	
Mesogastropoda	
Viviparidae	
<i>Lioplax subcarinata</i> , Waccamaw Scavenger 155	Endangered
Hydrobiidae	
<i>Amnicola</i> sp., Waccamaw Snail 156	Endangered
Pleuroceridae	
<i>Spirodon dilatatum</i> , Kanawha Riversnail 185	Undetermined
Basommatophora	
Planorbidae	
<i>Helisoma magnificum</i> , Cape Fear Ramshorn 171	Threatened
<i>Taphius eucosmius eucosmius</i> , Greenfield Ramshorn 170	Extinct?
Stylommatophora	
Endodontidae	
<i>Anguispira paucicostata</i> , Mt. Mitchell Snail 186	Undetermined
Polygyridae	
<i>Mesodon archeri</i> , Cherokee Helix 186	Undetermined
<i>Mesodon clarki nantahala</i> , Noonday Helix 173	Threatened
<i>Mesodon jonesianus</i> , Newfound Gap Helix 156	Endangered
<i>Mesodon orestes</i> , Avenger Helix 186	Undetermined
<i>Triodopsis soelneri</i> , Waccamaw Helix 174	Threatened
Bivalvia	
Heterodonta	
Unionidae	
<i>Alasmidonta triangulata</i> , Triangle Floater 187	Undetermined
<i>Alasmidonta varicosa</i> , Brook Floater 179	Special Concern
<i>Anodonta couperiana</i> , Barrel Floater 180	Special Concern
<i>Anodonta implicata</i> , Alewife Floater 188	Undetermined
" <i>Canthyria</i> " sp., Tar River Spiny Mussel 158	Endangered
<i>Carunculina pulla</i> , Savannah Shoremussel 159	Endangered
<i>Elliptio "lanceolata"</i> , Yellow Lance 181	Special Concern
<i>Elliptio marsupiobesa</i> , Cape Fear Spike 161	Endangered
<i>Elliptio</i> sp., Waccamaw Lance 175	Threatened
<i>Elliptio</i> sp., File Spike 189	Undetermined
<i>Elliptio waccamawensis</i> , Waccamaw Spike 162	Endangered
<i>Fusconaia masoni</i> , Atlantic Pigtoe 177	Threatened
" <i>Lampsilis</i> " <i>ochracea</i> , Tidewater Mucket 182	Special Concern
" <i>Lampsilis</i> " <i>radiata</i> complex, Lake Waccamaw population, Waccamaw Mucket 164	Endangered
<i>Ligumia nasuta</i> , Eastern Pondmussel 190	Undetermined

<i>Prolasmidonta heterodon</i> , Ancient Floater	168	Endangered
<i>Villosa constricta</i> , Notched Rainbow	184	Special Concern

SPECIES ACCOUNTS

GASTROPODA; MESOGASTROPODA; VIVIPARIDAE
(Livebearer Snails)

Lioplax subcarinata (Say)

WACCAMAW SCAVENGER

Description: A small snail, length about 13 mm (1/2 in.), with an operculum, carinate whorls, and usually straw colored shell. These characters will serve for identification because it is the only Carolinian *Lioplax*, and closely resembles no other snail in the Carolinas, and the only known population south of Virginia is restricted to Lake Waccamaw. An excellent illustrated review of this species' morphology and range was presented by Clench and Turner (1955), and it was additionally figured in Emerson and Jacobson (1976).

Distribution: Range -- discontinuous; basins of Potomac, Susquehanna, and Delaware rivers in Maryland, Pennsylvania, and Virginia; one population in North Carolina.

North Carolina -- Lake Waccamaw, Columbus Co.

Habitat and Mode of Life: The Waccamaw Scavenger characteristically burrows in sand and mud waterway floors, but appears readily susceptible to much fine sedimentation. In the latter respect it is oddly different from members of the closely related genus *Campeloma*, which thrive in fine muds. Some species of this genus are figured in Clarke (1973), Harman and Berg (1971), and others elsewhere. Like *Campeloma*, on the other hand, *L. subcarinata* is thought to devour small invertebrate animals and organic debris. In Lake Waccamaw it is moderately common in sand beneath shallow waters.

Reproduction: Judged by the Lake Waccamaw population, this snail can breed very successfully under congenial circumstances.

Status: *Endangered*. See Remarks below, and the account of *Elliptio waccamawensis*.

Remarks: The vernacular name introduced here refers to this species' alleged feeding mode and to Lake Waccamaw. To thus identify this population with its mother waterway is thought justified because, bereft of opportunity for interbreeding with its kind elsewhere, it is surely an isolate and an incipient species. An alternative common name, Keel'd Mystery Snail, was introduced by Emerson and Jacobson (1976).

References: Clarke (1973), Clench and Turner (1955), Emerson and Jacobson (1976), Harman and Berg (1971); see list following introduction.

Freshwater and Terrestrial Mollusks -- Accounts Endangered

GASTROPODA; MESOGASTROPODA; HYDROBIIDAE
(Faucet and Watercress Snails and relatives)

Ammicola sp.

WACCAMAW SNAIL

Description: A formal description of this species, new to science, is being prepared by Dr. Fred Thompson, a member of the Committee on Freshwater and Terrestrial Mollusks. Any description will have to await publication of this paper, but it can be noted here that this is a small form apparently restricted to Lake Waccamaw.

Distribution: Range -- an apparent North Carolina endemic; Lake Waccamaw, Columbus Co.

Habitat and Mode of Life: This snail is common in submerged vascular vegetation (F. G. Thompson, pers. comm.).

Status: *Endangered*. See the account of *Elliptio waccamawensis* (Status) later in this chapter.

Remarks: As intimated in the Introduction, the Waccamaw Snail is an excellent example of a species that could be extinguished before there is adequate opportunity to make it fully known to science and the public. It is likely that additional undescribed hydrobiids, some endemic and in great danger, are still undiscovered in North Carolina.

GASTROPODA; STYLOMMATOPHORA; POLYGYRIDAE
(Polygyras, Helices, and relatives)

Mesodon jonesianus (Archer)

NEWFOUND GAP HELIX

Description: Measuring about 13 mm (1/2 in.) in breadth, this snail so closely resembles two small congeners, *M. subpalliatum* (Pilsbry) and *M. wetherbyi* (Bland), that further descriptive remarks are pointless. Burch (1962) has made the distinctions among these three animals quite clear, but Pilsbry's (1940:758, Fig. 455) illustrations are incorrectly labeled: the smallest snail in his Figure 455a of *M. wetherbyi* is *Mesodon jonesianus*, and only the two larger snails in Figure 455c are *Mesodon jonesianus* (F. W. Grimm, pers. comm.).

Distribution: Range -- a few localities in the Newfound Gap region of North Carolina and Tennessee (Sevier Co.).

North Carolina -- western; Haywood and Swain cos.
(Hubricht 1970, 1973).

Habitat and Mode of Life: This species is restricted to moist forests of birch, beech, maple, and hemlock. Nothing else about its natural history has been published (but see below).

Status: *Endangered*. This species was listed as "rare" (DNER 1973) and "endangered" (Hubricht 1972). Because of its narrow range, great rarity, and specialized habitat, we consider it *Endangered*. The Newfound Gap region is included in the Great Smoky Mountains National Park, but, ironically, road building and clearing, and other activities designed to increase the recreational value of the Park, are a grave potential threat. We do not know of present direct threats to specific populations, and further research might indicate that the status of this form should be lowered. This would be highly desirable. On the other hand, other than the mixed blessing of inclusion in a National Park, no measures protective of this snail are in effect. We recommend a National Research Area for a radius of several miles around Newfound Gap. A potent avenue toward more immediate, legal protection of *M. jonesianus* is currently being explored; the U. S. Fish and Wildlife Service has proposed it as a nationally *Endangered* species, saying "This species lives in the humus zone very near to a parking area at Newfound Gap, North Carolina. Trampling of the forest litter can easily destroy this species. There are only an estimated 300 living individuals which are found only in birch, beech, maple, and hemlock forest in the Great Smoky Mountains National Park in Swain County, North Carolina." (*Federal Register* 1976, 41:17742-17747). If this proposal is approved, the Newfound Gap Helix will be protected by the provisions of Public Law 93-205.

Readers will have noted two difficulties inherent in the foregoing remarks. First, certain details in the Fish and Wildlife Service account of *M. jonesianus*, quoted above, are at variance with information gathered by this Committee and expressed above also. Clearly, each statement is based on partially superior data, and complements and strengthens the other. This does not affect the need to interpret the Newfound Gap Helix as *Endangered*, but emphasizes the need to continue researches concerning all species, especially those jeopardized by our activities. Second, neither this report, any ensuing legislation by North Carolina, nor any federal act, can be expected to ensure the safety of any organism without the continued and vigilant commitment of every citizen. The need to promote public awareness in this context is discussed in the Introduction to this chapter.

Remarks: The vernacular name introduced here, Newfound Gap Helix, refers to the lone region to which this species is believed to be restricted. An alternative name, Jones' Middle-toothed Land Snail, was used by the Fish and Wildlife Service in the *Federal Register* listing cited above.

References: Burch (1962), DNER (1973), Hubricht (1970, 1972), Pilsbry (1940); see list following introduction.
Hubricht, L. R. 1973. The land snails of Tennessee. *Sterkiana* 49:11-17.

BIVALVIA; HETERODONTA; UNIONIDAE
(Fresh-water Mussels)

"*Canthyria*" sp.

TAR RIVER SPINY MUSSEL

Description: As the only spinose mussel in North Carolina, this species can be confused with no other in the state. Also, it is apparently endemic to the Tar River. A formal taxonomic description is being prepared by Dr. D. H. Stansbery, Ohio State University; this will provide illustrations and additional identifying characters when published. Meanwhile, the student can depend upon the figure published in Shelley (1972).

Distribution: Range -- North Carolina endemic; Tar River.

Habitat and Mode of Life: The Tar River Spiny Mussel has been collected on sand and mud bottoms in shallow water, but its presence in muskrat middens (M. J. Imlay, pers. comm.) suggests that it also occurs in deeper water. Having been encountered on few occasions, it is presumed to be extremely rare, and little is known of its natural history, including the identity of any glochidial host or other aspects of its reproduction.

Status: *Endangered*. This species is extremely rare and endemic to a single river, an interpretation which supports the earlier (DNER 1973) state decision. The federal Office of Endangered Species, U. S. Fish and Wildlife Service, is contemplating *Endangered* registry for the species. No protective measures are currently in force, and none seems to be officially contemplated, but it is clear that the full length of the Tar River must be protected from adverse impacts if its Spiny Mussel is to be preserved. Research into distribution of this species is required in order that flourishing populations, if any exist, be located and protective measures be intensified in such areas. Also, the glochidial hosts, if any, must be identified. These measures are important in terms of pride in the natural wonders of North Carolina, and the esthetic and unique nature of this species. A more tangible reason for protection of the Tar River Spiny Mussel is its potential research value. Spiny mussels of unique species occur in the James River system of Virginia and the Altamaha of Georgia, as well as the Pamlico, which includes the Tar River. It seems probable that millenia ago there dwelt in the Atlantic drainage a genetically related "race" of spinose fresh-water mussels which is survived today by three modern species. Knowledge of the details of the presumed discontinuous natural extinction of this group would inform us greatly concerning the survival of fresh-water mussels, individually and as a group, and the advantage they can offer an ecosystem. The same is true in the case of *Prolasmidonta heterodon*, discussed later.

Remarks: It is unfortunate that in a report such as this, intended for a general readership, a full scientific name and description are not available for a given species. However, these are forthcoming for this mussel, and for the moment users can accurately be content with the vernacular name, Tar River Spiny Mussel, which is, obviously, derived from

the river to which the species is apparently restricted.

References: DNER (1973); see list following introduction.
Shelley, R. M. 1972. In defense of naiades. Wildlife in N. C.
36:4-8, 26-27.

Carunculina pulla (Conrad)

SAVANNAH SHOREMUSSEL

Description: A tiny species, whose shell rarely exceeds 26 mm (1 in.) in length. At maturity it is consistently the smallest freshwater mussel in the entire Atlantic drainage. The surface of the shell is commonly corrugated by prominent growth rings and the periostracum is coarse. There is conspicuous sexual dimorphism of shell and of the animal within. More specifically, the female is unique in the North Carolina fauna because of its caruncle. These characters, individually and in combination, ensure correct identification of this animal. It has been figured by Bates (1966), Emerson and Jacobson (1976), and Johnson (1970).

Distribution: Range -- Altamaha River system, Georgia, north into Cape Fear and Neuse river systems, North Carolina (Johnson 1970).

North Carolina -- only population known to have been thriving within last decade occurs or occurred in University Lake, near Chapel Hill, Orange Co. (J. P. E. Morrison, pers. comm.).

Habitat and Mode of Life: The Savannah Shoremussel favors shallow, still, or sluggish water at stream margins. No glochidial host is known for this species, but Wilson (1916) and Mermilliod (1973) recorded sunfishes and a bass (*Osteichthys*; Centrarchidae) as hosts of *C. parva* (Barnes) of the Mississippi basin and Gulf drainage. The host(s) of the Savannah Shoremussel may perhaps best be sought initially among centrarchid fishes. Nothing further is known, or realistically inferred, about important aspects of its natural history. Recent perennial observations on Bates' (1966) population of *C. pulla* indicate that, even in the presence of congenial habitat and glochidial hosts, this species has a low reproductive rate.

Status: *Endangered*. The great rarity of *Carunculina pulla* is sufficient justification for this assignment. Of the few published records, most are from North Carolina, but the only population known to thrive at present is that in the Savannah River described by Bates (1966) as *C. patrickae*. These, and the Orange County specimens, are the only living examples known to have been recorded for many years. There is an obvious decline in recorded occurrence of this species. It was not entered on former Carolinian lists of jeopardized organisms (DNER 1973, Nature Conservancy 1975), so the present listing is an important step toward conservation of this animal. No protective measures are in force, and preservation of the habitats of the Orange County, North Carolina, and Savannah River populations is crucial if it is to survive. Identification of at least the dominant natural host(s) of the glochidia is essential research for conservatory management of the species.

Remarks: Species of *Carunculina* "may be extremely abundant in a few inches' depth, following the water's rise and fall, seeking its margin (Clench and Turner 1956, Grantham 1969, Isely 1925, Murray and Leonard 1962, Utterback 1915-1916)." (Fuller 1974c). This activity appears to be characteristic of *C. pulla*. The vernacular name coined here reflects its usual habitat, as well as its customary occurrence in streams traversing Coastal Plain savannas, plus the fact that its healthiest known population occupies a portion of the river system of the same name. There exists another vernacular epithet, "Bankclimber," that is appropriate to species of the genus. It was originally associated with *Plectomerus dombeyanus* (Valenciennes), a common species in the Gulf and lower Mississippi basin drainages that belongs to another subfamily (Ambleminae) and bears no morphological resemblance to any *Carunculina*, and with *Lampsilis fallaciosa* 'Smith' Simpson, a widespread Mississippi basin mussel of debatable taxonomic validity or rank. The latter is more generally called the Slough Sandshell and, though of the same subfamily as *Carunculina* (Lampsilinae), looks very different from members of that genus (see Coker 1915). Accordingly, the expression "Shoremussel" is offered as an alternative. There are others. Murray and Leonard (1962) originated or adopted the name Lilliput Mussel for *C. parva*, another Mississippi basin species which, like most representatives of the genus, is typically of diminutive size. Presumably the reference is to Lilliput, the land of tiny people in Swift's *Gulliver's Travels*. Emerson and Jacobson (1976) coined Dusky Caruncle Mussel for *C. pulla* itself (as *Toxolasma pullum*). In this case the references are to the Latin adjective *pullus*, for "dark," as the color of its periostracum, and to the caruncle. We have chosen the name given here because it is more natural, more understandable, more euphonious, and less cumbersome than the extant alternatives, and because, in reference to "Lilliput," not all *Carunculina* are tiny. It is an ironic reflection on "the state of the art" that so much verbiage can be expended on the vernacular name of a species about which we know so little!

The members of the genus *Carunculina* pose an intimidating taxonomic challenge. Views on the numbers and names of true species in the genus range in time and character from Call's (1896) to the recent opinions of Johnson (1970, 1972) and Burch (1973, 1975b). Crawford's (1972) observations show that the female caruncle is a morphologically protean structure, which may have some value as an interspecific discriminant. This line of inquiry remains to be exploited, however, and extant concepts of speciation in *Carunculina* depend solely on conchological data. The correct number and nomenclature of Atlantic drainage species are moot, and the combination *C. pulla* is employed here for all Carolinian populations in deference to Johnson's debatable decisions.

- References: Burch (1973, 1975b), DNER (1973), Emerson and Jacobson (1976), Fuller (1974c), Johnson (1970), Wilson (1916); see list following introduction.
- Bates, J. M. 1966. A new species of *Carunculina* (Unionidae: Pelecypoda) from the Savannah River, South Carolina. Occas. Pap. Mus. Zool. Univ. Mich. No. 646:1-9.
- Call, R. E. 1896. A revision and synonymy of the *parvus* group of Unionidae. Proc. Indiana Acad. Sci. 1895:109-125.

- Coker, R. E. 1915. The common and scientific names of fresh-water mussels. U. S. Bur. Fish. Econ. Circ. No. 15:1-4.
- Crawford, M. J. 1972. Observations on some Louisiana Unionidae. Unpub. M. S. thesis, La. State Univ., Baton Rouge, LA. 67 pages.
- Johnson, R. I. 1972. The Unionidae (Mollusca: Bivalvia) of peninsular Florida. Bull. Fla. State Mus., Biol. Sci. 16:181-249.
- Mermillionid, W. 1973. An investigation for the natural host of the glochidia of *Toxolasma parva*. Undergrad. res. paper, La. State Univ., Baton Rouge, LA.
- Murray, H. D., and A. B. Leonard. 1962. Handbook of unionid mussels in Kansas. Univ. Kansas Mus. Nat. Hist. Publ. No. 28, Lawrence, KS. 184 pages.
- Nature Conservancy, The. 1975. Rare and endangered species of South Carolina. The Nature Conserv., Arlington, VA. 41 pages.

Elliptio marsupiobesa Fuller

CAPE FEAR SPIKE

Description: The rather small size, wedge-like shape, and shiny, yellowish periostracum of the shell of this species serve to distinguish it from other members of the genus. In addition, the gravid female bears a marsupium that is uncommonly obese for this genus. Illustrations were provided by Fuller (1972) and Burch (1975b).

Distribution: Range -- North Carolina endemic; unequivocally known only from several localities in Cape Fear River near Fayetteville, Cumberland and Bladen cos.; single specimen possibly referable to this species recently collected in the Northeast Cape Fear River.

Habitat and Mode of Life: The Cape Fear Spike has been found at and near the type locality only in a peculiar, coarse, yielding substrate composed of fine sediment mixed with finely divided clay and organic debris. The specimen from the Northeast Cape Fear River that may be this species was taken in deep, fine sediment. The greatly swollen marsupium of this species implies great larval production, and this correlates with the species' commonness at its type locality. That it appears to be neither abundant nor widespread suggests a damaged relationship to its glochicial host(s).

Status: *Endangered*. The species is known definitely only from three sites in the Cape Fear River in Bladen and Cumberland counties. This reach of the river receives some organic enrichment, presumably from Fayetteville and neighboring municipalities, as well as sedimentation from probable sheet erosion (ANSP 1971). These factors alone are sufficient to jeopardize most fresh-water mussels, but, in view of this species' tolerance of a certain amount of sediment, threats to its glochicial host(s) are probably a greater difficulty. The gradual attrition of the Cape Fear Spike under these circumstances is highly probable, but a more immediate threat is posed by proposed or authorized dams and impoundments above Fayetteville (USACE 1975). The usual effects of dams, including cold water bottom-release and an "artificial tide" regime, minimize shallow water habitats and their suitability to mussels, as well as many other

forms of aquatic life. No protective measures are known to be in effect or proposed for the Cape Fear Spike. Reconsideration of the impoundment activities referred to above, improvement of extant and prospective municipal and industrial effluents, measures for curbing point and non-point sources of erosion, and identification of its glochidial host(s), all are things that can contribute to preservation of this handsome and unusual animal that is peculiar to the state of North Carolina.

Remarks: In its slender lateral outline, with pointed posterior, *Elliptio marsupiobesa* resembles *E. dilatata* (Rafinesque) of the Mississippi basin and Gulf drainage, a not closely related congener that is commonly called Ladyfinger or Spike. The latter name is especially appropriate to the shape of this species and similar Atlantic drainage members of the genus. This fact, and recognition of the river to which *E. marsupiobesa* is presumably unique, lie at the root of the vernacular name coined for this report.

References: Burch (1975b), USACE (1975); see list following introduction.
ANSP. 1971. Cape Fear River surveys 1969-1970 for E. I. duPont de Nemours & Company. Dept. Limnol. Acad. Nat. Sci. Phila., Philadelphia, PA. 112 pages.
Fuller, S. L. H. 1972. *Elliptio marsupiobesa*, a new fresh-water mussel from the Cape Fear River, North Carolina. Proc. Acad. Nat. Sci. Phila. 124:1-10.

Elliptio waccamawensis (Lea)

WACCAMAW SPIKE

Description: This species is readily distinguished from other *Elliptio* in the state by its limited range, angular lateral outline, and very sharp posterior shell ridge (Figures 1 and 2). Conchologically somewhat similar animals occur in the Waccamaw River as far south as Horry County, South Carolina. The shell is easily confused with that of males of the Lake Waccamaw population representing the "*Lampsilis*" *radiata* complex. The differences are discussed in the "*L. radiata*" account, and compare Figures 1 and 3. Illustrations of this species were published by Burch (1973, 1975b), Emerson and Jacobson (1976), and Johnson (1970).

Distribution: Range -- North Carolina endemic; only recorded from, and apparently restricted to, Lake Waccamaw, Columbus Co.

Habitat and Mode of Life: The preferred habitat is shallow-water areas and the clean- or muddy-sand floor of Lake Waccamaw. In spite of the fame of the Waccamaw Spike and the ease with which it could be studied, almost nothing is known about its natural history. It is reasonably assumed that the glochidial host(s) occur among the Lake Waccamaw ichthyofauna as considered by Hubbs and Raney (1946). However, J. H. Gillespie (pers. comm.) has developed electrophoretic evidence that several of the species described by these authors scarcely differ genetically from populations in the Waccamaw River basin below the lake.

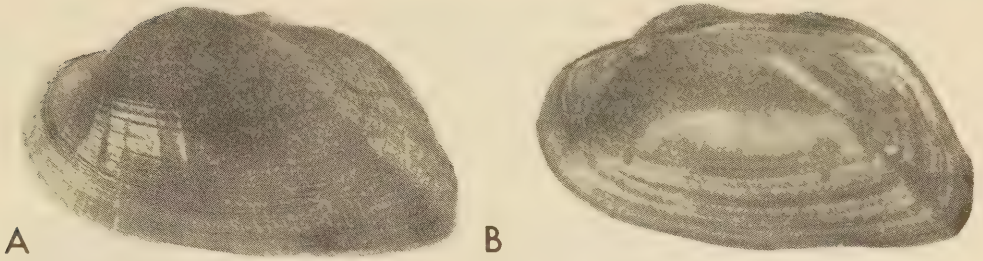


Figure 1. Lateral view of a juvenile shell of *Elliptio waccamawensis*, the Waccamaw Spike. Lake Waccamaw, Columbus County. Anterior left, posterior right in both figures. A. Outer (periostracal) surface. B. Inner (nacreous) surface. Actual length 36 mm. Note: inflation (breadth) of shell; radial, sculpted and/or pigmented rays on anterior surface; sharply carinate (keeled) posterior ridge; and raised radial sculpture on posterior slope. The "box-like" character of the outlines and surface ordinarily abates with age. Compare with the Waccamaw Mucket (Figure 3).

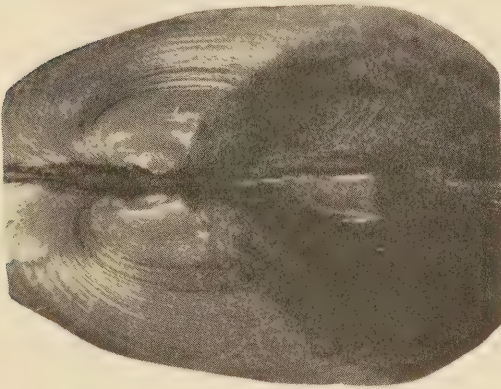


Figure 2. Magnified dorsal view of shell in Figure 1. In addition to characters mentioned above, note the "beak sculpture", the few, concentric ridges on the umbones or oldest part of the shell, which is typical of the genus *Elliptio*.

Status: *Endangered*. The Waccamaw Spike's very restricted geographical range would alone qualify it for this category, but the accelerating land development that promises ultimately to girdle Lake Waccamaw guarantees the terminal jeopardy of most of its denizens. Unless this change is subjected to the most assiduous quality control, the still rather pristine sands of the lake floor will become befouled by sediment, plus organic materials and their attendant vegetable growth. Such changes are inimical to most lacustrine benthic organisms. The present trend toward centralized sewerage in the community of Lake Waccamaw (K. E. Wright, pers. comm.) could have results either beneficial or disastrous for the lake. In addition, use of the herbicide Silvex in canals adjacent to the lake probably endangers its inhabitants, including mussels (DNER 1973). Knowledge of the Waccamaw Spike's glochidial host(s) would facilitate efforts to conserve this species. Its *Endangered* status, as determined by this Committee, is consistent with earlier opinions: "rare and endangered" (Stansbery 1971), "endangered" (DNER 1973), and "rare throughout entire range and in danger of extinction" (Heard 1975).

Honesty compels us to note that the Waccamaw Spike is not "rare" at present, though it promises to be so soon.

Remarks: The rationale supporting the vernacular name, Waccamaw Spike, is analogous to that used in the case of the Cape Fear Spike, *E. marsupiobesa*.

References: Burch (1973, 1975b), DNER (1973), Emerson and Jacobson (1976), Heard (1975), Johnson (1970), Stansbery (1971); see list following introduction.
Hubbs, C. L., and E. C. Raney. 1946. Endemic fish fauna of Lake Waccamaw, North Carolina. Miscell. Publ. Mus. Zool. Univ. Michigan No. 65:1-30.

"Lampsilis" radiata (Gmelin) complex,
Lake Waccamaw population

WACCAMAW MUCKET

Description: The population in question is considered unique by members of this Committee (Fuller, Imlay, and Williams) who conducted a naiad survey of the Waccamaw River basin, and adjacent basins and sub-basins, just prior to the Symposium. This mussel exhibits conspicuous sexual dimorphism of the shell, and the female resembles no other species in Lake Waccamaw, while the male is conchologically almost indistinguishable from *Elliptio waccamawensis* of either sex (Figures 1 and 3). However, the postbasal mantle margin of the Waccamaw Mucket is darkly pigmented (Figures 5 and 6) in both sexes, whereas this is true of neither sex of the Waccamaw Spike. A sense of the differences between the Waccamaw Mucket and related Carolinian populations can be gained by comparing Figures 3 through 6. Illustrations of more or less conchologically typical morphs (or subspecies) in the "*L.*" *radiata* complex can be found in Athearn and Clarke (1962), Burch (1973, 1975b), Clarke (1973), Clarke and Berg (1959), Emerson and Jacobson (1976), Johnson (1970), and Ortmann (1919).

Distribution: Range -- North Carolina endemic; confined to Lake Waccamaw, Columbus Co. Similar but distinguishable populations occur sporadically in the river below the lake.

Habitat and Mode of Life: The "*Lampsilis*" *radiata* complex is wide-ranging in North America. Understandably, an enormous variety of habitats is involved. Atlantic drainage members of this complex, on the other hand, are most characteristic of tidal portions of rivers and creeks, and of waterways (like Lake Waccamaw) close to the sea. Populations do, of course, occur much farther upriver in certain basins. They favor a clean, sand bottom, but a softer, muddy bottom is sometimes tolerated. Regardless of habitat type, few populations have yet been detected in North Carolina. Most of them, like the Waccamaw Mucket, flourish at present.

Reproduction: One at least nominal member of the "*Lampsilis*" *radiata* complex, "*L.*" *r. luteola* of the Mississippi basin and perhaps elsewhere, uses a large number and variety of glochidial hosts (Fuller 1974c). Complementary information was provided by Kakonge (1972) and Tedla and Fernando (1969 and others). It is unsound to impute one mussel's hosts

to another, even closely related, species, but to infer from the information above that the Waccamaw Mucket has more than one host seems very reasonable. Refer to the discussion of *Elliptio waccamawensis* immediately preceding.

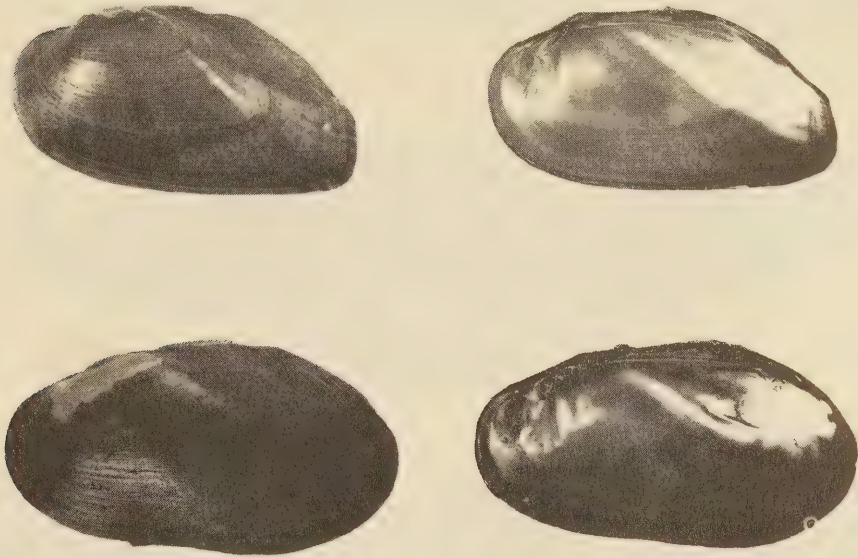


Figure 3. Lateral views of male (above) and female (below) shells of the Lake Waccamaw representative of the "*Lampsilis*" *radiata* complex (Waccamaw Mucket). See Figure 1 for positioning. Actual length of male 57 mm, female 65 mm. Note degree of sexual dimorphism (compare with Figure 4), and resemblance of male shell to that of the Waccamaw Spike (Figure 1).

Status: *Endangered*. The rationale is essentially identical to that for *Elliptio waccamawensis* above.

Remarks: The vernacular name chosen for the Lake Waccamaw population derives from the fact that the name "Mucket" has long been of widespread use for species of *Lampsilis* and conchologically similar genera in the Mississippi basin. An irony is that the "*L.*" *radiata* group is not true *Lampsilis* at all. In *Lampsilis* the female postbasal mantle margin is modified into a fish-like flap whose entirety can move in a sinuous fashion, thus serving as a lure for predatory fish. When these disturb the flap they also disturb the nearby marsupium, and are showered with glochidia. Kraemer (1970) wrote an interpretation somewhat at variance with this, the traditional one. In the "*L.*" *radiata* complex, on the other hand, the postbasal mantle margin is comparatively poorly modified. It is rather broad, roughened, and deeply pigmented (Figures 5 and 6), to be sure, but there is no piscine flap, and motor activity is confined to a region a short distance anterior from the incurrent mantle aperture. Here the

mantle margin consists of a ribbon of tissue (Figure 5), which can be extruded from between the valves of the shell and then retracted suddenly. On the other hand, this "ribbon" is obsolete in some specimens (Figure 6). These morphic and functional modifications of the postbasal mantle margin are unique. They appear to have been mentioned first by Welsh (1969), whose observations were recently confirmed in the Mississippi basin and Atlantic drainage by two members of this Committee (Fuller and Imlay). We are preparing a new genus-group name for this complex of mussels.

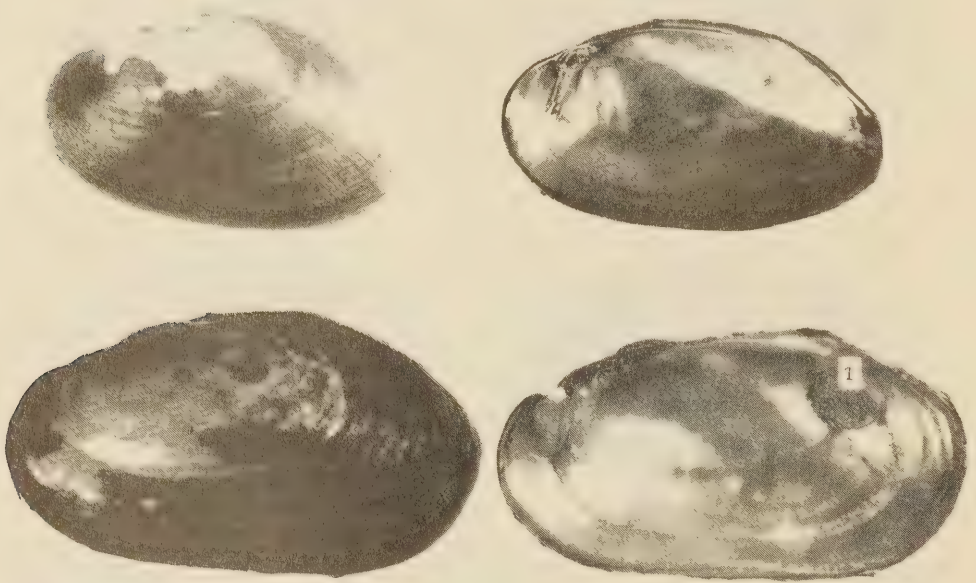


Figure 4. Lateral views of male (above) and female (below) shells of the Orton's Pond, Brunswick County, representative of the "*Lampsilis*" *radiata* complex. Actual length of male 64 mm, female 79 mm. Note lesser degree of sexual dimorphism compared with Figure 3. Also note malformed ("blister") pearls on posterior adductor muscle scar (1) and anterior along pallial or mantle scar. These can be induced by viruses and/or unionicolid water mites (Fuller 1974c). The notch in the upper left margin of the female valve is from erosion and/or corrosion of the shell, part of the pathology of mussel senescence.

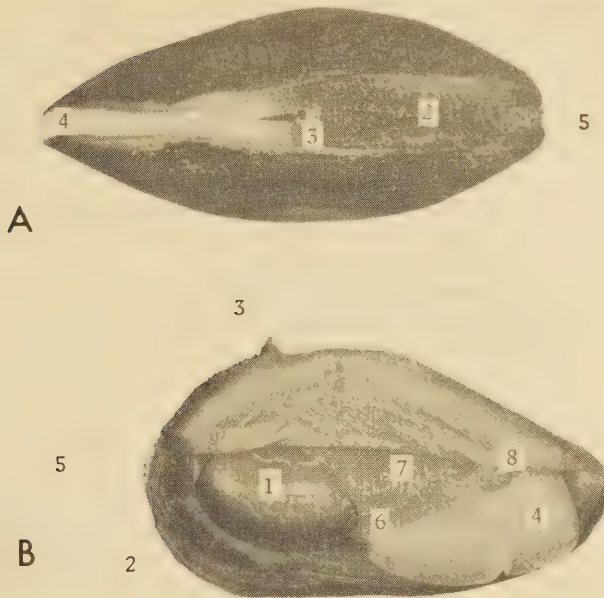


Figure 5. Ventral (A) and lateral (B) views of females from the Orton's Pond population. Actual length ca. 80 mm. In A anterior is left. In B posterior is left, the right shell valve has been removed, and the underlying mantle sheet has been everted upwards (dorsad). Note: charged or loaded marsupium of left gill (1); broad, rough (papillose), and darkly pigmented postbasal mantle margin (2); "ribbon" of tissue on postbasal margin (3); foot (4); incurrent mantle aperture (5); anterior part of inner demibranch of gill (6); non-marsupial portion of outer demibranch of gill (7); and labial palpi (8). These features may serve as an introduction to the internal morphology of fresh-water mussels, but species other than "*Lampsilis*" *radiata* exhibit different details of the marsupium and postbasal mantle margin.

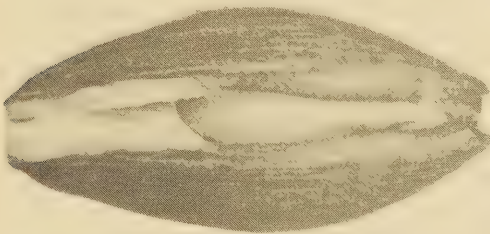


Figure 6. Ventral view of a gravid female of the "*L.*" *radiata* complex from the Kennebec River, Maine. Actual length ca. 80 mm. Note absence of a "ribbon" of tissue along mantle margin (see Figure 5).

Although more weakly developed than in Figure 5, pigment extends the length of mantle margin (see Figure 9). Such specimens occasionally occur in Carolinian populations. The charged marsupium of the left gill is visible within the posterior mantle cavity.

References: Burch (1973, 1975b), Clarke (1973), Clarke and Berg (1959), Emerson and Jacobson (1976), Fuller (1974b,c), Johnson (1970), Ortmann (1919), Tedla and Fernando (1969); see list following introduction.

Athearn, H. D., and A. H. Clarke, Jr. 1962. The freshwater mussels of Nova Scotia. Nat. Mus. Canada Bull. No. 183, Contr. Zool., 1960-1961: 11-41.

Kakonge, S. A. K. 1972. The ecology of some metazoan parasites of, and their effect on, small stream fishes and fry. Unpub. Ph.D. dissert., Univ. Waterloo, Ontario, Canada. 163 pages.

Kraemer, L. R. 1970. The mantle flap in three species of *Lampsilis* (Pelecypoda: Unionidae). *Malacologia* 10:225-282.

Welsh, J. H. 1969. Mussels on the move. *Natural History* 78:56-59.

Prolasmidonta heterodon (Lea)

ANCIENT FLOATER

Description: This is a small mussel, whose shell rarely achieves so much as 38 mm (1 1/2 in.) of length. The epithet *heterodon* ("different tooth") emphasizes the chief distinguishing characteristic of this species, which is the only known North American fresh-water mussel that consistently has two lateral teeth on the right valve, but only one on the left. All other laterally dentate Nearctic species have two lateral teeth on the left valve and one on the right. However, atypical lateral dentition can occur in this species, as well as in others. Accordingly, the beginning student of North Carolina mollusks should be aware of other discriminants for this species: female shells are somewhat more obese (i.e., laterally inflated) than those of males, and shells of both sexes become increasingly arcuate with advancing age. In North Carolina, the Ancient Floater can be confused only with young members of the genus *Elliptio*, from which it can be distinguished by its mottled but colorful mantle margin. Useful aids in identification include Burch (1973, 1975b), Clarke and Berg (1959), Emerson and Jacobson (1976), Johnson (1970), and Ortmann (1919).

Distribution: Range -- Atlantic drainage; North Carolina, sporadically north into Canada.

North Carolina -- Neuse (Johnson 1970, Walter 1956) and Pamlico (D. H. Stansbery, pers. comm.) river systems.

Habitat and Mode of Life: Very little is known about the natural history of the Ancient Floater. However, something may be said of its habitat, which is itself none too clear. It is usually encountered in stable stream floors of sand and/or fine gravel, but, like most other members of the subfamily Anodontinae, it has a considerable tolerance of sediment overlying formerly clean streambeds.

Reproduction: This species is known to breed in winter (Ortmann 1919). Its extensive and broken range suggests (1) that several fishes serve as glochidial hosts, but none has been implicated (Fuller 1974c); and (2) that these host species, like the mussel itself, exhibit rather strong preferences for certain habitats whose disturbance leads to elimination of host and parasite alike.

Status: *Endangered*. The Ancient Floater's relict distribution suggests that it was already failing prior to settlement by European and African man. Also, because of its small size, it was probably no more than an occasional and inadvertent item in the diet of aboriginal man and certain other mammals known to prey upon fresh-water mussels, like the raccoon and muskrat. Habitat destruction is hastening *P. heterodon* toward extinction. Although recent discoveries have expanded knowledge of its range, the number of known populations is dwindling. We are aware of a healthy population in Connecticut that was eliminated from a tiny, sandy stream by sedimentation from construction of a single house. The only thriving population known to us occurs in New Hampshire, and the last "stronghold" of the species appears to be the Connecticut River system of New England. In North Carolina this species is in great jeopardy. The only recently discovered specimens are from the Tar River, and, despite numerous attempts, Walter's (1956) 20-year-old Neuse River records have not been confirmed.

The Ancient Floater remains one of the most rare, elusive, and vulnerable mollusks in the state and the nation. Our deliberations have confirmed an earlier decision (DNER 1973) to confer endangered status upon this species, support Clarke's (1970) contention that this form (as *Alasmidonta heterodon*) is probably endangered, and verify Stansbery's (1971) contention that it is "rare and endangered." The federal Office of Endangered Species is preparing to register it in the same status nationwide. No protective measures have yet been provided for the species, but the prospect of its addition to the federal list is encouraging. It is obvious that any effort to curb any form of pollution would benefit any species, endangered or otherwise, but such efforts would be especially practicable and beneficial in the case of this species, whose known populations are so few. A program of protection of specific habitats at specific localities should be implemented at once, especially with reference to thriving populations. There is reason to believe that they might yet be effectively guarded and preserved. Coordination of federal, state, and local laws would be required. In North Carolina there must also be an effort to discourage further channel modifications of the Neuse and Tar rivers and their tributaries.

While the Ancient Floater lacks great and unequivocal value in commercial and esthetic terms, it has great significance in biological science. As one of rather few North American fresh-water mussels with a naturally relict distribution, this species still offers an opportunity to learn much about what is necessary to a mussel's survival. That sort of information is invaluable for our efforts to save other organisms. Apart from legal and physical protection, this species needs research into various aspects of its biology, especially the identity and nature of its dominant glochidial host in the wild. Protection of the latter may be the salvation of the former.

Remarks: The naturally discontinuous range and its suggestion of great antiquity are responsible for the vernacular name, Ancient Floater, newly coined for this report, and for the elevation here of the sub-generic name, *Prolasmidonta*, to generic rank. Additional support for this taxonomic adjustment is the presence of lateral teeth and of sexual dimorphism of the shell. Both characters are foreign to members of the genus *Alasmidonta*, where the Ancient Floater is usually classified. On

Freshwater and Terrestrial Mollusks -- Accounts Probably Extinct

the other hand, both are typical of *Pegias fabula* (Lea), also often placed in *Alasmidonta*, but the shells of these two species are quite unlike (Blankenship 1971; Burch 1973, 1975b; Neel and Allen 1964). Emerson and Jacobson (1976) have offered an alternative common name, Inverted Mussel, for this species.

- References: Burch (1973, 1975b), Clarke and Berg (1959), DNER (1973), Emerson and Jacobson (1976), Fuller (1974c), Ortmann (1919), Stansbery (1971), Johnson (1970); see list following introduction.
- Blankenship, S. 1971. Notes on *Alasmidonta fabula* (Lea) in Kentucky. *Nautilus* 85:60-61.
- Clarke, A. H., Jr. 1970. Papers on the rare and endangered mollusks of North America. Discussion of Dr. Stansbery's paper. *Malacologia* 10: 21-22.
- Neel, J. K., and W. R. Allen. 1964. The mussel fauna of the upper Cumberland basin before its impoundment. *Malacologia* 1:427-459.
- Walter, W. M. 1956. Mollusks of the upper Neuse River basin, North Carolina. *J. Elisha Mitchell Sci. Soc.* 72:262-274.

GASTROPODA; BASOMMATOPHORA; PLANORBIDAE
(Ramshorn Snails)

Taphius eucosmius eucosmius Bartsch

GREENFIELD RAMSHORN

Description: This snail, recorded only from Greenfield Pond, Wilmington, is readily distinguishable from other Carolinian planorbids. It is very small, about 6 mm (1/4 in.) in breadth, and has "two rather broad, bright chestnut bands" against a "yellowish horn color" background (Bartsch 1908).

Distribution: Range -- North Carolina endemic; type and only known population lived (or lives) in Greenfield Pond, Wilmington, New Hanover Co.

Habitat and Mode of Life: The only account of this species ever written (Bartsch 1908) did not include a description of its habitat. We infer that it is rather like that of *Helisoma magnificum*, the Cape Fear Ramshorn, discussed later. Nothing is known about any aspect of its natural history, including reproduction.

Status: Presumed *Extinct*. All attempts by members of the Committee to find this animal in recent years have failed. This viewpoint essentially replicates that expressed earlier (DNER 1973) as "endangered" and "possibly extinct."

Remarks: In the same paper describing this form, Bartsch (1908) also described *T. e. vaughani* from Louisiana. Within recent years J. P. E. Morrison (pers. comm.) found the latter subspecies alive and, on the basis of this material, suspects that Bartsch's taxa are better referred to the

Central American genus *Taphius* than to *Planorbis*. If this interpretation proves correct, and if these two animals are conspecific, the Greenfield Ramshorn should be called *Taphius e. eucosmius*. Derivation of the vernacular name is obvious.

References: Bartsch (1908), DNER (1973); see list following introduction.

Helisoma magnificum (Pilsbry)

CAPE FEAR RAMSHORN

Description: This rare species resembles other, more commonly encountered, Ramshorns, which are natural objects familiar to naturalists, watermen, aquarists, and rural fossickers alike. Exceeding 25 mm (1 in.) in any given dimension, this is the North American giant of its family. Its angular, swollen aspect also serves to separate it from other Carolinian planorbids, which are smaller and/or coplanar. It was figured by Pilsbry (1903) and Wolf (1908).

Distribution: Range -- North Carolina endemic; Greenfield Pond, Wilmington, New Hanover Co. Questionable in Orton's Pond, near Wilmington, and lower Cape Fear River.

Habitat and Mode of Life: Bartsch's (1908) account provides the only relevant information. He found the species common in uprooted vascular vegetation that, he inferred, had probably been blown inshore from deeper waters of the pond. The inference is reinforced by his observation that the adults are blind.

Reproduction: In a largely unsupervised, and sometimes abandoned, "experiment," Bartsch (1908) was able to "induce" breeding, as well as great mortality. Wolf (1908), the incomparable pioneer aquarist, apparently never had an opportunity to rear this species. Also see Status.

Status: *Threatened*. In spite of the very limited known range and number of populations of *Helisoma magnificum*, as well as its possible extinction, we have elected to place this species in this category on the strength of J. P. E. Morrison's (pers. comm.) report of enormous, presumably planorbid eggs in Orton's Pond near Wilmington some years ago. If Morrison's suspicion that these were eggs of the Cape Fear Ramshorn can be proven correct, this snail would stand every chance of being successfully conserved, because this pond persists as a wildlife refugium, in effect. On the other hand, premature jubilation should be somewhat allayed. Pilsbry's (1903) "type locality" was probably in error, and Bartsch (1908) failed to find this species elsewhere than Greenfield Pond in spite of apparently assiduous search. To search for it today in the Cape Fear or any other river, or in any lentic body of water, is doubtless hopeless. In view of its not being mentioned in Baker's (1945) monumental monograph on the family Planorbidae, this Ramshorn was evidently not available to him, more than three decades ago. Also, at the time of his Orton's Pond investigation, Morrison did not find this species at Greenfield Pond, and three members of this Committee (Fuller, Imlay, and Williams) failed to discover it there in November, 1975. An intensive

search for surviving populations of the species is needed; to find that it lives would be a dramatic feather in the Tarheel cap. Understanding of its adult blindness could shed light upon aspects of human medicine, and we have here a potentially important experimental animal. Any efforts to preserve or improve environmental quality at Greenfield or Orton's Pond would be of great value.

Remarks: Pilsbry (1903) ascribed his original specimens to the lower Cape Fear River. Judging by its inflated shell, rather fragile for one so large, Bartsch (1908), whose account of the matter reads rather as a detective story, suspected that this species was an inhabitant of quiet waters. He traveled to southeastern North Carolina and, triumphantly, found the object of his search living populously in Greenfield Pond. That Pilsbry's ascription was incorrect is probable; that Greenfield Pond is (or was) the only locality productive of the species, more so (but see Status, above).

Two nomenclatural problems are relevant here. First, Pilsbry (1903) described the Cape Fear Ramshorn in the genus *Planorbis*. Modern practice has been to refer this species to *Helisoma*. Best generic ascription of planorbid species depends upon knowledge of soft-tissue anatomy, but these aspects of this species are scarcely described (Bartsch 1908). The correct generic placement of *H. magnificum* remains moot, although conchological characters certainly argue for *Helisoma*. The second problem concerns the vernacular name. Wolf (1908) introduced Cape Fear River Snail for this species. The appellation "Riversnail" is best reserved for members of the family Pleuroceridae. In addition, there is no reason to suppose that the Cape Fear River is relevant to this snail. However, partially in deference to Wolf, who was in at least some respects before his time, we choose to name this species for the peninsula or basin (but not necessarily the river) Cape Fear. The word "Ramshorn" has long been of widespread use for members of the Planorbidae because of the characteristic shape of most of their shells. A winning, alternative common name for *H. magnificum*, Magnificent Ram's Horn, was contributed by Emerson and Jacobson (1976). The name Giant Ramshorn is a likely alternative that might be considered by the as yet non-existent group that will eventually standardize the vernacular names of Nearctic non-marine mollusks.

References: Baker (1945), Bartsch (1908), Emerson and Jacobson (1976); see list following introduction.
Pilsbry, H. A. 1903. The greatest American *Planorbis*. *Nautilus* 17: 75-76.
Wolf, H. T. 1908. The molluscs, vermes and hydrozoa of freshwater. In: Goldfish Breeds and Other Aquarium Fishes. Innes, Philadelphia, PA.:215-248.

GASTROPODA; PULMONATA; POLYGYRIDAE
(Polygyras, Helices, and relatives)

Mesodon clarki nantahala (Clench and Banks)

NOONDAY HELIX

Description: Since this species, like *M. jonesianus*, has several conchologically similar congeners, we refrain from a possibly misleading verbal description. Refer to the accounts and figures provided by Clench and Banks (1932) and Pilsbry (1940).

Distribution: Range — possible North Carolina endemic; Nantahala Gorge and Handpole Brook, Swain Co. (Hubricht 1970); may occur elsewhere, including nearby Tennessee.

Habitat and Mode of Life: This species forages in litter of wooded slopes.

Status: *Threatened*. The geographic range of *M. c. nantahala* is probably at least as restricted as that of the *Endangered* species, *M. jonesianus* (discussed earlier), but the ambiguous taxonomic rank of this at least nominal subspecies, and our limited knowledge of it, lead us to place the Noonday Helix in this category. Earlier opinions (Hubricht 1972, DNER 1973) interpreted this Helix as "endangered." The U. S. Fish and Wildlife Service has proposed that *M. c. nantahala* be federally registered as a *Threatened* species, saying: "This species is restricted to the Blowing Spring area of Nantahala Gorge and Handpole Brook in Swain County, North Carolina. Widening of U. S. 19 to four lanes, as has been proposed, could destroy most of the known colonies of this subspecies."

Remarks: The Noonday Helix is a nominal subspecies whose current taxonomic and biological status may be that of a subspecies (Pilsbry 1940) or a species (Clench and Banks 1932). We have followed Pilsbry's interpretation, which is more recent and sophisticated. However, the relationship of the snail to *M. clarki* (Lea) and its many forms remains unresolved. If the Nantahala Gorge form of *M. c. clarki* proves to be a unique biological entity, the Noonday Helix is probably endangered in virtue of its apparently narrow geographic and ecologic range. If not, this animal probably deserves no jeopardy status at all. This is a good example of the sort of creature that requires further research before an unequivocal "ruling" on its status in this context can be made.

The vernacular name introduced in this report depends upon the fact that, according to Stewart (1970), in Cherokee "nantahala" means "'middle (noonday) sun,' originally applied to a place where perpendicular cliffs kept the sun from shining until noon." An alternative is "Clark's Nantahala middle-toothed land snail," provided by the U. S. Fish and Wildlife Service.

References: DNER (1973), Hubricht (1970, 1972), Pilsbry (1940); see list following introduction.
Clench, W. J., and G. S. Banks. 1932. Descriptions of some land snails of southwestern North Carolina. *Nautilus* 46:14-18.
Stewart, G. R. 1970. *American Place-names*. Oxford Univ. Press, N. Y., NY. 550 pages.

Triodopsis soelneri (J. B. Henderson)

WACCAMAW HELIX

Description: The following combination of identifying characters is drawn chiefly from Grimm (1975) and Burch (1962): size about 13 mm (1/2 in.); periostracum dark red-brown and shiny; spire moderately domed; whorls 4.5 to 5.0 in number; umbilicus scarcely perforate; and aperture teeth limited to one lengthy, low, arcuate parietal tooth. The shell was figured by both authors, and Pilsbry (1940). The lip is broad, white, and reflected in adults, and thin and sharp in juveniles. An additional, unillustrated discussion of morphology is in Vagvolgyi (1968).

Distribution: Range -- North Carolina endemic; small area between Lumber and Cape Fear rivers in parts of Bladen, Brunswick, Columbus, and Jones counties (Grimm 1975, Hubricht 1970).

Habitat and Mode of Life: The Waccamaw Helix is a native of piney woods or cypress swamps. About one snail per 10 square meters can be found during wet periods, but congregations appear in association with trash on the woodland floor.

Reproduction: At least under laboratory conditions, the Waccamaw Helix has rather high fecundity. Snails will lay clutches of six to eight eggs every month or two throughout the year. In nature the species is little less prolific. They are not very active during the hottest parts of summer, and hibernate only during the coldest periods of winter.

Status: *Threatened*. The adaptability of *T. soelneri* to man's activities was intimated above. Clearing land, draining swamps, and the like probably will not extinguish this species, but it is threatened with extinction as a subtle, indirect consequence of man's modifying woodlands. The geographic range of *T. soelneri* partially overlaps that of *T. fallax messana* Hubricht, a closely related form that is presently tolerant of a wider variety of habitats, including roadsides (Grimm 1975), which is an unnatural habitat. Hybrids between these two taxa (figured in Grimm 1975) are known, and we fear that habitat disturbance will provide opportunity for accelerated hybridization until pure *T. soelneri* is eliminated as a genetic entity. The phenomenon has precedent: *T. f. vannostrandii* (Bland) is being absorbed genetically by *T. f. fallax* (Say) and *T. f. hopetonensis* (Shuttleworth) in disturbed habitats through much of its range. Genetic disappearance of the Waccamaw Helix may be considered. Our decision on its status represents an advance beyond an earlier opinion (Clarke 1970) that this animal is possibly in some degree of jeopardy.

Remarks: The common name of this snail refers to the fact that most of its scattered populations occur in the Waccamaw basin. Recent apprehension that the species will be lost by hybridization contrasts sharply with the scarcely decade-old work by Vagvolgyi (1968), who emphatically referred to the morphological integrity of the Waccamaw Helix.

References: Burch (1962), Hubricht (1970), Pilsbry (1940); see list following introduction.
Clarke, A. H., Jr. 1970. Papers on the rare and endangered mollusks of

North America. (See D. S. Dundee's discussion of Dr. Clench's paper).
Malacologia 10:36-37.

Grimm, F. W. 1975. Speciation within the *Triodopsis fallax* group (Pulmonata: Polygyridae) -- a preliminary report. Bull. Amer. Malacol. Union Inc. 1974:23-29.

Vagvolgyi, J. 1968. Systematics and evolution of the genus *Triodopsis* (Mollusca: Pulmonata: Polygyridae). Bull. Mus. Comp. Zool. 136:145-254.

BIVALVIA; HETERODONTA; UNIONIDAE
(Fresh-water Mussels)

Elliptio sp.

WACCAMAW LANCE

Description: The shell of this mussel is long and narrow in lateral view, its dorsal and ventral margins are almost parallel, and its ends are oddly blunt (Figure 7). This animal appears to be restricted to Lake Waccamaw, although other sources (e.g., DNER 1973) have indicated it (as *Elliptio folliculata*) elsewhere. Whether or not the Waccamaw Lance is legitimately to be considered a species remains moot, but it is certainly a morphologically and probably genetically unique population, and thus deserves to be considered a unique biological entity. This population belongs conchologically to the group of *E. lanceolata* (Lea) and might be confused with other members of the complex, one of which is illustrated herein (Figure 8).



Figure 7. Lateral views of the shell of an aged Waccamaw Lance, a member of the *E. lanceolata* complex. Lake Waccamaw, Columbus County. Actual length 93 mm. Erosion and corrosion of the periostracum, and "blister pearls," both pathological features, are visible on the external and internal surfaces of the shell, respectively.

Distribution: Range -- North Carolina endemic; unequivocally known only from Lake Waccamaw, Columbus Co.

Habitat and Mode of Life: The Waccamaw Lance is especially common in slightly muddy sand among submerged vascular plants, under several feet of water.

Reproduction: This species is obviously reproductively successful in congenial habitat and in the presence of one or more glochidial hosts. These may be sought among those fishes listed by Hubbs and Raney (1946) for Lake Waccamaw.

Status: *Threatened*, and quite likely *Endangered*. The latter assignment would be in harmony with previous assessments of the Waccamaw Lance (as *Elliptio folliculata*, at least in part) as "rare" (DNER 1973) and "rare and endangered" (Stansbery 1971). Comments made under Description above, and the discussion of *E. waccamawensis* provided earlier, are pertinent.



Figure 8. Lateral views of the shell of a member of the *E. lanceolata* complex from the Chowan River, Gates County. Actual length 86 mm. Note the dissimilarity between this morph and the Waccamaw Lance (Figure 7). This shell could pass for *Ligumia nasuta*, but the two are easily separated by soft-tissue discriminants (compare Figures 9 and 14).

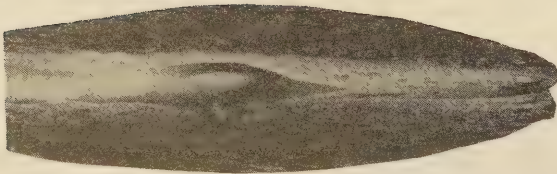


Figure 9. Ventral view of the postbasal portion of another specimen of the *E. lanceolata* complex from the Chowan River population. Mantle margin features that are characteristic of *Ligumia nasuta* are absent (Figure 14).

Remarks: The group of *E. lanceolata* is in need of taxonomic revision, which will probably clarify the nomenclatural status of the population known here as the Waccamaw Lance. For the time being, this vernacular name is used to designate the population in question (but see Figure 8). In any event, the Waccamaw Lance appears to be a unique animal by whatever name. This common name is drawn from the name of

the typical lake and from the membership of this population in the *E. lanceolata* complex.

References: DNER (1973), Stansbery (1971); see list following introduction.

Hubbs, C. L., and E. C. Raney. 1946. Endemic fish fauna of Lake Waccamaw, North Carolina. Miscell. Publ. Mus. Zool. Univ. Michigan No. 65:1-30.

Fusconaia masoni (Conrad)

ATLANTIC PIGTOE

Description: The shell of this mussel reaches little more than about 38 mm (1 1/2 in.) in length, and in lateral view is shaped rather like a rhombus. The lateral outline is variable, however, as is the color. Figures are in Burch (1975a) and Fuller (1974a). The latter paper also figures the soft tissues, several of whose characters are important in identification: the marsupium occupies the entire gill, and its contents (ova or glochidia) are usually a vivid shade of red like much of the tissues, especially the muscles. These characters are unique among North Carolina mussels. Also, the incurrent papillae are arborescent, a feature shared in the state only by the common *Unio merus tetralasmus* (Say), not considered in this report. The latter, however, has a very different shell (see Burch 1975b, Pennak 1953, and others). The Atlantic Pigtoe can be confused in North Carolina only with populations in the *Elliptio crassidens* complex, animals often with nondescript shells much like that of *F. masoni*, which were amply figured by Johnson (1970). Among other Atlantic drainage naiads it can be confused with *Lexingtonia subplana* (Conrad), but this species has only been confirmed from the James River system of Virginia (Ortmann 1914).

Distribution: Range -- Chowan system in Virginia, south into Ogeechee basin of Georgia.

North Carolina -- only known extant population in Cape Fear River near Fayetteville, Cumberland Co., at type locality of *Elliptio marsupiobesa* (Fuller 1972, 1974a); Johnson (1970) indicated others (see Remarks). Shells of recently dead individuals recorded from Rocky River system, Chatham Co. (R. M. Shelley, pers. comm.).

Habitat and Mode of Life: The Atlantic Pigtoe prefers clean, sandy streambeds of creeks or small rivers. Living in the characteristic substrate of *E. marsupiobesa*, the one known Cape Fear River population of *F. masoni* is atypical of the species. Its rarity throughout its range suggests poor coordination with at least its dominant glochidial host(s) in nature.

Reproduction: Barren in autumn and gravid in late spring (Fuller 1974a), this species appears to be bradytictic. Under conditions congenial in terms of host(s) and habitat, it reproduces adequately, but its rarity suggests some breakdown in these relationships.

Status: *Threatened*. Because of the very limited known distribution of the Atlantic Pigtoe in North Carolina and elsewhere, it is definitely

vulnerable to environmental disturbance. For example, further impoundment threatens the Cape Fear River population, as well as the *Endangered* species, *Elliptio marsupiobesa*. Although this population is the only one known in the state at this time, it is likely that there are others, and only *Threatened* status seems warranted. Further research into Carolinian mussel distribution may well support ultimate *Endangered* status. Other needed research must be concerned with identifying and protecting its glochidial host(s). Unfortunately, no protective measures of any kind are currently available to the species. This is especially unfortunate because it figures prominently in ongoing research into evolution and other aspects of the biology of fresh-water mussels. The Atlantic Pigtoe is additionally significant as the only tetrageous mussel in the Atlantic drainage, a distinct biogeographical province. As such, the Cape Fear River population (and possibly others) figures among the unique zoological features of North Carolina. This Committee's decision to interpret the mussel as *Threatened* is an understandable sequel to earlier opinions. "*Fuscinia merris*" has been considered "rare and endangered" (Nature Conservancy 1975). This misspelling probably represents "*Fusconaia merus* [mera]" which probably refers to *Unio merus* Lea, a taxon based on Savannah River basin material from South Carolina and probably a synonym of *F. masoni* (see Johnson 1970; Fuller 1974a, 1975). Heard (1975) described this species, as *Pleurobema (Lexingtonia) masoni*, corrected to *Fusconaia masoni*, in these terms: "very rare or extinct in part of present or past range, respectively".

Remarks: All of Johnson's (1970) records of *Pleurobema masoni* below the James basin are probably *F. masoni*. There is little likelihood of "contamination" by *Lexingtonia subplana*. The name "Pigtoe" is widely used in reference to Mississippi basin and Gulf drainage members of *Fusconaia* and conchologically similar genera. Fuller (1974c) introduced the name Atlantic Pigtoe for this species because it is the only representative of this vernacular group in the Atlantic drainage.

References: Burch (1975a,b), Fuller (1974a,c), Heard (1975), Johnson (1970), Pennak (1953); see list following introduction.
Fuller, S. L. H. 1972. *Elliptio marsupiobesa*, a new fresh-water mussel (Mollusca: Bivalvia: Unionidae) from the Cape Fear River, North Carolina. Proc. Acad. Nat. Sci. Phila. 124:1-10.
_____. 1975. Fresh-water mussels (Mollusca: Bivalvia) in the Chowan river system of Virginia. ASB Bull. 22:54. Abstract.
Nature Conservancy, The. 1975. Rare and endangered species of South Carolina. The Nature Conserv., Arlington, VA. 41 pages.
Ortmann, A. E. 1914. Studies in najades (Part 3). Nautilus 28:28-34.

The five species of fresh-water mussels discussed below are considered to be of *Special Concern* in North Carolina. They and/or their populations in the state are believed or known to be in varying degrees of jeopardy, but are not considered to be in imminent danger of extinction or threatened by definite phenomena. Further research will probably demonstrate that some or all should be reassigned, doubtless to a higher category in most cases.

BIVALVIA; HETERODONTA; UNIONIDAE
(Fresh-water Mussels)

Alasmodonta varicosa (Lamarck)

BROOK FLOATER

Remarks: This species is easily distinguished from other Carolinian mussels by a unique combination of characters: (1) elongate shape; (2) vivid coloration (yellow to orange) of muscle tissues, especially the foot; (3) weak pseudocardinal teeth and obsolete laterals; and (4) radial ridges on the posterior slope. Good illustrations were published by Clarke and Berg (1959), Johnson (1970), and Burch (1973, 1975b). The Brook Floater is known to range from the Savannah River system in South Carolina into the St. Lawrence system in Canada (Johnson 1970). Its characteristic habitat is the sand floors or gravel riffles of small, upland, rapidly flowing, oxygen-rich streams in upper portions of river systems. This species is a relative rarity throughout its range, but it has a certain metropolis in New England, where this sort of stream is called a brook -- hence the vernacular name. The status of *A. varicosa* is based on its rarity; it has been recorded only twice in North Carolina. Fortunately, there are some additional, unpublished records for the state, notably in the Cape Fear River system (R. M. Shelley, pers. comm.). Howard and Anson (1922) identified glochidial hosts of the closely related *A. marginata*, a characteristically Mississippi River basin congener. As listed by Fuller (1974c), these may serve as reliable guides to establishing the identities of glochidial hosts of the Brook Floater. Such research would be in the very best interest of this species, as would be any additional biological information. Because of the scattered, upland, small-stream nature of its favored habitat, the chief probable danger to the species is non-point-source pollution that could physically damage its habitat and/or poison it and its larval hosts. These kinds of adversity can endanger organisms so subtly and rapidly that Heard's (1975) ominous opinion of the Brook Floater as "rare throughout entire range and in danger of extinction", though perhaps partly ill informed, could suddenly become fact. In addition, scientific and avocational collecting can damage individual populations, while posing no threat to the species unless too extensive.

References: Burch (1973, 1975b), Clarke and Berg (1959), Fuller (1974c), Heard (1975), Johnson (1970); see list following introduction. Howard, A. D., and B. J. Anson. 1922. Phases in the parasitism of the Unionidae. *J. Parasitol.* 9:68-82.

Anodonta couperiana Lea

BARREL FLOATER

Remarks: The newly introduced common name is, in great measure, a play on words compounded of its conchological obesity and the word "cooper" (or the Middle English "couper"), a maker of barrels. Emerson and Jacobson (1976) have suggested another common name, Couper's Freshwater Mussel.

The Barrel Floater is most abundant and commonly encountered in peninsular Florida, but it ranges northward in the Atlantic drainage into at least the Cape Fear River basin of North Carolina (Johnson 1965, 1970, 1972; Fuller 1971), where it has not been frequently encountered. Because it is at the periphery of its range in this state and thus understandably rare, we have interpreted it as of *Special Concern*, but not due to man's activities. Indeed, as a Floater, it is tolerant of slack water, sedimentation, and other consequences of drainage modification, so impoundments probably pose it little or no threat. This species can be confused in North Carolina with a common close relative, *Anodonta imbecillis*, the Paper Floater, but the latter's dorsal and ventral margins are subparallel and almost straight, whereas the ventral margin of *A. couperiana* is convexly rounded. Johnson (1965) made the differences clear, and other aids in identification include Johnson (1970, 1972), Burch (1973, 1975b), and Emerson and Jacobson (1976).

It appears that no glochidial hosts are yet known for the Barrel Floater (Fuller 1974c), but Heard (1975) has provided interesting information about other aspects of its reproduction. This species includes populations with many hermaphroditic individuals, a commonplace in the genus, and breeds during a brief period of winter, which is atypical of the genus. Heard (1975a) has expressed the belief that *A. couperiana* is "very rare or extinct in part of present or past range, respectively". This contrasts with this Committee's assessment and its forerunner (DNER 1973), that the Barrel Floater is of undetermined status in North Carolina. Heard's point of view was based largely upon observations on this species in its metropolis, and further data may well demonstrate that our opinion is naive, and that *A. couperiana* is in grave danger in this state.

References: Burch (1973, 1975b), DNER (1973), Emerson and Jacobson (1976), Fuller (1974c), Heard (1975), Johnson (1970); see list following introduction.

- Fuller, S. L. H. 1971. Macroinvertebrates (exclusive of insects). In: Cape Fear River surveys 1969-1970 for E. I. duPont de Nemours & Co. Dept. Limnol. Acad. Nat. Sci. Phila., Philadelphia, PA. pp. 28-37, 105-107.
- Heard, W. H. 1975a. Sexuality and other aspects of reproduction in *Anodonta* (Pelecypoda: Unionidae). *Malacologia* 15:81-103.
- Johnson, R. I. 1965. A hitherto overlooked *Anodonta* (Mollusca: Unionidae) from the Gulf drainage of Florida. *Breviora* No. 213:1-7.
- _____. 1972. The Unionidae (Mollusca: Bivalvia) of peninsular Florida. *Bull. Fla. State Mus., Biol. Sci.* 16:181-249.

Elliptio lanceolata (Lea)

YELLOW LANCE

Remarks: The fresh-water mussel genus *Elliptio* (Spikes and Lances) includes elongate representatives (the Lances) in the southern Atlantic and eastern Gulf of Mexico drainages. The most recent monographic treatment of Lances in the Atlantic drainage is that of Johnson (1970), who recognized three species: *E. shepardiana* (Lea) of the Altamaha River basin of Georgia, which has nothing to do with the animal under consideration here; *E. arctata* (Conrad), originally described from the Mobile River basin in Alabama, whose occurrence anywhere in the Atlantic drainage was questioned by Fuller (1972); and *E. lanceolata* (Lea), which Johnson thought to range in the Atlantic drainage from Pennsylvania into Georgia. This last taxon is the earliest described of the Lances and, accordingly, the one to which all other relevant taxa in the Atlantic drainage and elsewhere must be compared. During recent years, Johnson's concept of *E. lanceolata* has been attacked. There can be little doubt that the "*lanceolata*-group" of *Elliptio* includes more than one biological species of mussel (Fuller 1971, 1972; Johnson 1970, 1972; Ortmann 1919; and others). It is probable that *E. angustata* (Lea) is such a one. This at least nominal species has been fairly well characterized by Blood (1975), Morrison (1972, 1973), and Riddick (1973). Judged by Johnson's descriptions and illustrations, *E. lanceolata* has a yellowish shell of gently rounded lateral outline, whereas *E. angustata* has a darker shell of subrectangular lateral outline. They were originally described from the Cooper and Tar rivers in South and North Carolina, respectively. Unfortunately, the relationships of these species (or morphs) to their congeners remain imperfectly described. The yellow, essentially North Carolinian entity is thought to be in jeopardy, but the confusion between it and *E. angustata* is great and thought to be responsible for the following at least partly contradictory opinions. *Elliptio angustata* has been considered "rare and endangered" by D. H. Stansbery (Nature Conservancy 1975). *Elliptio lanceolata* was thought "rare and endangered" (Stansbery 1971) and "rare" (DNER 1973), but Heard (1975) stated that this taxon is "not rare and endangered, although at least once listed as so". These contrasting appraisals cast doubt upon the wisdom of including any Atlantic drainage Lance in this report, but there is no doubt that at least one such biological entity is in some jeopardy in North Carolina.

- References:** DNER (1973), Heard (1975), Johnson (1970), Ortmann (1919), Stansbery (1971); see list following introduction.
- Blood, F. B. 1975. A morphometric identification key of the Unionidae (Mollusca: Bivalvia) in the Pamunkey River system, Virginia. Unpub. MS thesis, Va. Commonwealth Univ., Richmond, VA. 40 pages.
- Fuller, S. L. H. 1971. A brief field guide to the fresh-water mussels (Mollusca: Bivalvia: Unionacea) of the Savannah River system. ASB Bull. 18:137-146.
- _____. 1972. An undescribed structural feature in the marsupium of *Elliptio lanceolata* (Lea 1828) (Unionidae). Nautilus 86:85-86.
- Johnson, R. I. 1972. The Unionidae (Mollusca: Bivalvia) of peninsular Florida. Bull. Fla. State Mus., Biol. Sci. 16:181-249.
- Morrison, J. P. E. 1972. Sympatric species of *Elliptio* in North Carolina. Bull. Amer. Malacol. Union 37:38-39.

- Morrison, J. P. E. 1973. Sympatric species of *Elliptio* in the St. Johns River, Florida. Bull. Amer. Malacol. Union 38:14.
- Nature Conservancy, The. 1975. Rare and endangered species of South Carolina. The Nature Conserv., Arlington, VA. 41 pages.
- Riddick, M. B. 1973. Freshwater mussels of the Pamunkey River system, Virginia. Unpub. MS thesis, Va. Commonwealth Univ., Richmond, VA. 105 pages.

"Lampsilis" ochracea (Say)

TIDEWATER MUCKET

Remarks: This species includes an enormous Lake Waccamaw population (Figure 14), which, like all populations in this lake, is in danger. The only additional and extant known populations in North Carolina apparently occur in the tidal Chowan River near Eure, Gates County, and in the Tar River near Pinetops, Edgecombe County (R. M. Shelley and K. E. Wright, respectively, pers. comm.). The Tidewater Mucket is doubtless more widespread in the state, but until this is established it should be considered of *Special Concern*. The Waccamaw population has special significance for North Carolina and natural science because it is the only really large one known.

"Lampsilis" ochracea ranges from the Savannah River system in Georgia northward in the Atlantic drainage into Canada (Johnson 1970). Throughout this range it can be confused with *L. cariosa* (Say), the Yellow Mucket, which is a true *Lampsilis* (see the earlier account of the Lake Waccamaw representative of the group of "*L. radiata*"). As such, it has a piscene mantle flap, whereas the Tidewater Mucket has none (Figure 16). This simple discriminant readily separates these two species, and shell material is usually separable with reference to Johnson (1947, 1970), Clarke and Berg (1959), Ortmann (1919), Burch (1973, 1975b), and Emerson and Jacobson (1976). The Tidewater Mucket also has a characteristic ecological range. Although not actually confined to tidal portions of river systems, it is never found far from the Atlantic coast. This suggests that, like the Alewife Floater (see *Anodonta implicata*), its dominant glochidial host is an anadromous fish. Little else is known or believed about this mussel's reproduction. It is evidently bradytictic (Johnson 1970) and capable of great population development in congenial circumstances. Favorable habitat is usually a sandy floor beneath shallow water, often in lakes and smaller streams. Varying habitat can induce ecophenotypic conchological variation in this species, but the soft tissues preserve an essentially constant character. This character is unique among naiades and requires creation of a new genus for the Tidewater Mucket (Fuller and Bereza, in preparation). Morrison's (1975) assignment of this species to the Mississippi basin and western Gulf drainage genus *Leptodea* (Paper Shells) is in error (Bereza and Fuller 1975). The vernacular name that we have chosen for this mussel refers to its optimal habitat and to the fact that in the Mississippi basin "Mucket" is commonly applied to shells of *Lampsilis* and of members of genera that conchologically resemble that genus (Coker 1915). An alternative name, Ocher Lamp Mussel, proposed by Emerson and Jacobson (1976), refers to an ordinary color of the shell and to the presumed etymology of *Lampsilis* (but see Rafinesque 1820, and Lindahl 1906).

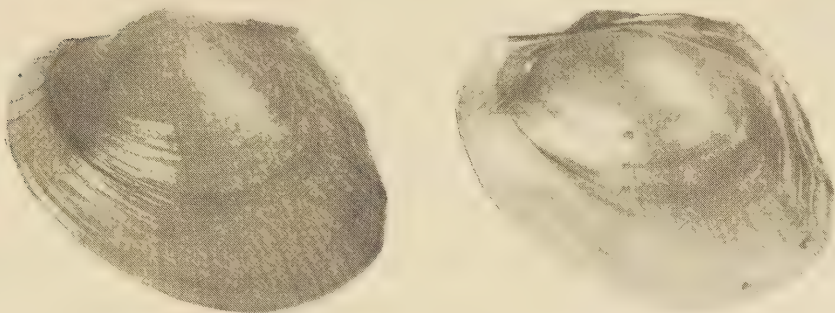


Figure 10. Lateral views of the shell of a juvenile female Waccamaw Mucket, "*Lampsilis*" *ochracea*. Lake Waccamaw, Columbus County. Actual length 31 mm. Compare with Figure 11, a mature female from a riverine population.

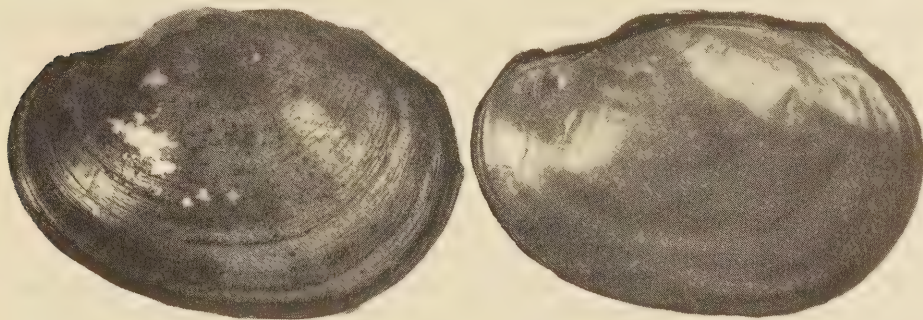


Figure 11. Lateral views of the shell of an adult female "*Lampsilis*" *ochracea* from the Chowan River, Gates County. Actual length 75 mm. Compare with the juvenile female from a lacustrine population above.

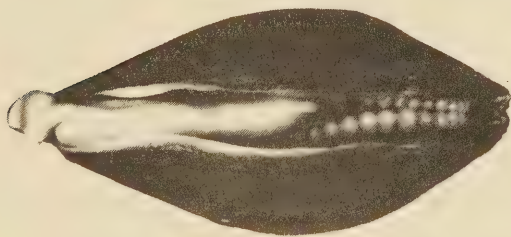


Figure 12. Ventral view of a gravid female "*Lampsilis*" *ochracea* from the Chowan River population. Actual length 71 mm. The charged marsupia of both gills are conspicuous within the posterior portion of the mantle

cavity (compare with Figures 5 and 6). Note the absence here of the broad, papillose, and usually highly pigmented postbasal mantle margin (commonly bearing a "ribbon" of tissue) which is characteristic of the *radiata* group. Note the foot and incurrent mantle aperture (see Figure 5), and the fewer, more discrete portions ("ovisacs") of the marsupium in comparison with the marsupium in Figure 6.

References: Burch (1973, 1975b), Clarke and Berg (1959), Emerson and Jacobson (1976), Johnson (1970), Ortmann (1919); see list following introduction.

- Bereza, D. J., and S. L. H. Fuller. 1975. Notes on "*Lampsilis*" *ochracea* (Say)(Mollusca: Bivalvia). ASB Bull. 22:42. Abstract.
- Coker, R. E. 1915. The common and scientific names of fresh-water mussels. U. S. Bur. Fish., Econ. Circ. No. 15:1-4.
- Johnson, R. I. 1947. *Lampsilis cariosa* Say and *Lampsilis ochracea* Say. Occas. Pap. on Mollusks 1:145-156.
- Lindahl, J. 1906. Orthography of the names of the Naiades. J. Cincinn. Soc. Nat. Hist. 20:235-243.
- Morrison, J. P. E. 1975. Maryland and Virginia mussels of Lister. Bull. Amer. Malacol. Union Inc. 1974:36-39.
- Rafinesque, C. S. 1820. Monographie des coquilles bivalves fluviatiles de la rivière Ohio, contenant douze genres et soixante-huit espèces. Annales Generales des Sciences Physiques 5:287-322.

Villosa constricta (Conrad)

NOTCHED RAINBOW

Remarks: This is a small species, rarely achieving 38 mm (1 1/2 in.) in length, with usually black periostracum and pronounced sexual dimorphism. The posterior end of the female shell is constricted, pinched, or notched -- hence the specific epithet and the vernacular name. This character is unique among Atlantic drainage naiades. Good figures occur in Johnson (1970) and Burch (1973, 1975b), and these publications also permit facile separation of the Notched Rainbow from other, sympatric *Villosa*. This species ranges from the Santee-Cooper system into the James system of Virginia, and there are numerous records for North Carolina (Johnson 1970). These are scattered, however, and, while *V. constricta* is hardly a rare animal, it is not common and is seldom plentiful. Because of these data and because of extant and proposed waterway modifications in North Carolina we consider the Notched Rainbow of *Special Concern* here. Nothing is known of its reproduction. The favored habitat is a clean, sand floor among rocks in the shallows of a smaller, often upland stream, though it will occur in rivers and in mud.

References: Burch (1973, 1975b), Johnson (1970); see list following introduction.

The seven species considered below are of *Undetermined* status because so little is known about them, either in general or in North Carolina. Further knowledge will probably necessitate assigning some of them otherwise, doubtless to categories of greater jeopardy in some cases.

GASTROPODA; MESOGASTROPODA; PLEUROCERIDAE
(Riversnails)

Spirodon dilatatum (Conrad)

KANAWHA RIVERSNAIL

Remarks: Like almost all Pleuroceridae, the genus *Spirodon* is in taxonomic confusion and has received little or no attention since Tryon's (1873) monograph and Goodrich's work (catalogued by Rosewater 1959). This situation will be greatly remedied by two forthcoming studies, a monograph of *Spirodon* and a catalogue of the Pleuroceridae, both by W. J. Clench, who has provided most of the information on which this account is based. The Kanawha Riversnail occurs in the Kanawha and Monongahela River drainages of the Ohio River sub-basin and, in North Carolina, is known from at least four localities in the New River drainage, in Alleghany, Ashe, and Watauga counties. A proposed dam across the New River that would create Moores Ferry Lake in Grayson County, Virginia, and Alleghany County, North Carolina, would surely destroy most if not all populations of fluviatile mollusks that it affected, including this species, which requires rapidly moving, well oxygenated water over a rocky substrate. However, the Ashe and Watauga county populations of the snail should not be harmed by this project. Accordingly, although the Kanawha Riversnail has been listed as *Endangered* in North Carolina (DNER 1973), it probably does not warrant any rank beyond *Undetermined*. Further research into the geographic and ecologic distributions, as well as the population structures, of North Carolina and other *S. dilatatum* would be rewarding, and might reveal that it is in greater jeopardy at state and/or national levels than we know. Such investigation, unfortunately, would be immediately impeded by difficulty in identifying this animal. In North Carolina it is readily confused with its Atlantic drainage counterpart, *S. carinata* (Brugière), which ranges from the upper Pee Dee River basin in North Carolina northward into the Susquehanna basin in Pennsylvania. Each of these two species is so conchologically variable that to illustrate either in a manner less than monographic is pointless and misleading. Refer to Clench's forthcoming monograph, and to Tryon's (1873) account of "*Anculosa*" *dilatata*. The rationale for the vernacular name, Kanawha Riversnail, should be clear from the foregoing remarks.

References: DNER (1973), Tryon (1873); see list following introduction.
Rosewater, J. 1959. Calvin Goodrich; a bibliography and catalogue of his species. Occas. Pap. on Mollusks 24:189-208.

GASTROPODA; STYLOMMATOPHORA; ENDODONTIDAE
(Endodontid Land Snails)

Anguispira paucicostata Kutchka

MOUNT MITCHELL SNAIL

Remarks: This is a great rarity that is known only from Mount Mitchell, North Carolina, and may be extinct. In any case, it should be sought assiduously in an effort to clarify its status and to resolve relevant taxonomic problems. The species may be only a "freak" representative of some other member of this genus, but it appears to be valid. It may be anticipated on logs, in ravines, and in and on talus at night after rain, when snails are commonly most active. Pilsbry (1948) figured this snail, and his work must be consulted in any effort to distinguish this species or morph from its congeners. It has twice been listed as *Endangered* (DNER 1973, Hubricht 1972). Derivation of the vernacular name used here should be obvious from the previous remarks. Every North Carolina naturalist can be excited by the mystery that surrounds the Mount Mitchell Snail, which is perhaps the rarest of zoological oddities in the state. The person is to be congratulated who next finds this snail alive, damages no living specimens, and reports the discovery in a responsible fashion.

References: DNER (1973), Hubricht (1972), Pilsbry (1948); see list following introduction.

GASTROPODA; STYLOMMATOPHORA; POLYGYRIDAE
(Polygyras, Helices, and relatives)

Mesodon archeri Pilsbry

CHEROKEE HELIX

Remarks: The Cherokee Helix is admitted to this report on the strength of its probable occurrence in North Carolina. It was originally described from nearby Polk County, Tennessee. The species was figured by Pilsbry (1940) and Burch (1962). Little or nothing has been published in regard to its natural history. The rationale behind our status assignment should be clear in view of these remarks. Equally obvious is the necessity of research into its biology, including its presence or absence in this state. Our common name for the species introduced in this report is in respect for the Cherokee Nation, which included the region inhabited by the Cherokee Helix. The species has elsewhere been listed as *Endangered* (Hubricht 1972).

References: Burch (1962), Hubricht (1972), Pilsbry (1940); see list following introduction.

Mesodon orestes Hubricht

AVENGER HELIX

Remarks: Almost nothing is known of this species, recently described and illustrated by Hubricht (1975). The type and apparently only known locality is Waterrock Knob, Blue Ridge Parkway, Haywood County, North Carolina, at an elevation of 1,860 m (6,200 ft.). The status of the Avenger Helix will probably adjust upward once more is learned about

it. The vernacular name refers to the attributes of Orestes, a mountain-dwelling figure in Greek mythology who avenged the murder of his father, Agamemnon, by slaying his mother, Clytemnestra, and Aegisthus.

Editor's Note: There is probably no sadder story in the annals of molluscan lexicography.

References: Hubricht, L. R. 1975. Four new species of land snails from the eastern United States. *Nautilus* 89:1-4.

BIVALVIA; HETERODONTA; UNIONIDAE
(Fresh-water Mussels)

Alasmidonta triangulata (Lea)

TRIANGLE FLOATER

Remarks: This Floater was not recorded from North Carolina by Johnson (1970). Its inclusion in this report depends upon Fuller's (1971) record of a single juvenile *Alasmidonta* of debatable identity from the Cape Fear River near Fayetteville, Cumberland County. The interested student is hereby alerted to the possible presence of the Triangle Floater in this state. It is known in the Atlantic drainage from the Ogeechee, Savannah, and Santee-Cooper river systems in Georgia and South Carolina. Its detection in North Carolina will depend on distinguishing it from the closely related *A. undulata* (Say), which, according to Johnson (1970), ranges from the Santee-Cooper system northward through the Atlantic drainage into southern Canada. In addition to Johnson's monograph, aids in the identification of the Triangle Floater are Burch's manuals (1973, 1975b). Almost nothing is known of the natural history of *A. triangulata*. The two specimens recorded by Fuller (1974b) from the Savannah River were taken in muddy sand beneath less than 61 cm (2 ft.) of water. There can be no doubt that this species is naturally a great rarity, and its prospects for survival are poor, considering these forbidding points of view: "rare and endangered" in the eastern Gulf of Mexico drainage (Athearn 1970); "rare and endangered" (Stansbery 1971); "rare and endangered" in South Carolina (Nature Conservancy 1975); and "rare throughout entire range and in danger of extinction" (Heard 1975). It is probable that the Triangle Floater is presently represented by so few individuals that research in the interest of conservation is by now out of the question. The only hope is that relaxation or elimination of point- and non-point-source stresses might promote a resurgence of the species. Although logically of *Undetermined* status in North Carolina, this species is assuredly *Endangered* in the nation.

References: Burch (1973, 1975b), Fuller (1974b), Heard (1975), Johnson (1970), Stansbery (1971); see list following introduction. Athearn, H. D. 1970. Discussion of Dr. Heard's paper. In: A. H. Clarke, Jr. (Ed.). Papers on the rare and endangered mollusks of North America. *Malacologia* 10:28-31. Fuller, S. L. H. 1971. Macroinvertebrates (exclusive of insects). In: Cape Fear River surveys 1969-1970 for E. I. duPont de Nemours & Company. Dept. Limnol. Acad. Nat. Sci. Phila., Philadelphia, PA. pp. 28-37, 105-107.

Nature Conservancy, The. 1975. Rare and endangered species of South Carolina. The Nature Conserv., Arlington, VA. 41 pages.

Anodonta implicata Say

ALEWIFE FLOATER

Remarks: The Alewife Floater ranges from southern Canada southward in the Atlantic drainage into the Potomac River basin in the District of Columbia (Johnson 1970). This was the accepted range of this species until R. M. Shelley (pers. comm.) collected and correctly verified the identity of a specimen from the upper Cape Fear River basin in North Carolina. Nothing else is known about the Alewife Floater in the state, but a few additional points may help with research into this species. Useful aids in identification include Ortmann (1919), Johnson (1946, 1970), Clarke and Berg (1959), Burch (1973, 1975b), and Emerson and Jacobson (1976). The species can be confused only with *A. cataraeta* Say, the Pond Floater, with which it is often sympatric, but the former can be distinguished by its typically much thicker and heavier shell with coppery nacre, uniformly dark periostracum, and greatly thickened anteroventral margin. Largely confined to lower portions of river systems, *A. implicata* has a characteristic distribution, much like the Tidewater Mucket discussed earlier in species of *Special Concern*. This distribution probably depends on the migratory habits of the Alewife, *Alosa pseudoharengus* (Osteichthys; Clupeidae), which is the mussel's dominant glochidial host in nature (Johnson 1946). Davenport and Warmuth (1965) implicated several other species during laboratory experiments. The relationship between the Alewife and its Floater is an especially graphic example of the almost universal and utter dependence of mussels on fish. Specifically, recent resurgence of *A. implicata* and local domination by this species of the formerly much more plentiful *A. cataraeta* in the Connecticut River system, Hartford County, Connecticut, may be correlated with increasingly successful Alewife runs resulting from improved water quality (Fuller, unpub.). Clearly, the Alewife Floater can reproduce with great success in favorable circumstances, but, with the exception that it appears to be bradytictic (Johnson 1946, 1970), nothing further is known about its reproduction. The derivation of the vernacular name should be obvious. An alternative name, Confused River Mussel, is available (Emerson and Jacobson 1976); the reference is to the Latin *implicatus*, "confused".

References: Burch (1973, 1975b), Clarke and Berg (1959), Emerson and Jacobson (1976), Johnson (1970); see list following introduction. Davenport, D., and M. Warmuth. 1965. Notes on the relationship between the freshwater mussel *Anodonta implicata* Say and the alewife *Pomolobus pseudoharengus* (Wilson). *Limnol. & Oceanogr.* 10:R74-R78. Johnson, R. I. 1946. *Anodonta implicata* Say. *Occas. Pap. on Mollusks* 1:109-116. Ortmann, A. E. 1919. A monograph of the naiades of Pennsylvania. Part III. Systematic account of the genera and species. *Memoirs Carnegie Mus.* 8:1-384.

Elliptio sp.

FILE SPIKE

Remarks: This indeterminate (and perhaps new) species is known from the very large Lake Waccamaw population, and would be considered officially *Endangered* by this Committee were there not another, conchologically similar form common in Orton's Pond near Wilmington, New Hanover County, which is quite safe at present. Lacking further information, we interpret the File Spike as of *Undetermined* status for the moment. At least the Lake Waccamaw population (Figure 13) can be separated from sympatric *Elliptio* by its yellow-brown periostracum, subrectangular outline, and raised growth rests (file-like to the touch), to which the common name refers. Nothing further is known of this animal's natural history. It can be confused with *Unio* *tetralasmus*, but the latter has arborescent papillae at the incurrent aperture and none at the excurrent (Fuller 1971), whereas any *Elliptio* has simple papillae at both. References in aid of identifying *U. tetralasmus* are provided in the account of *Fusconaia masoni*, a *Threatened* species discussed earlier.

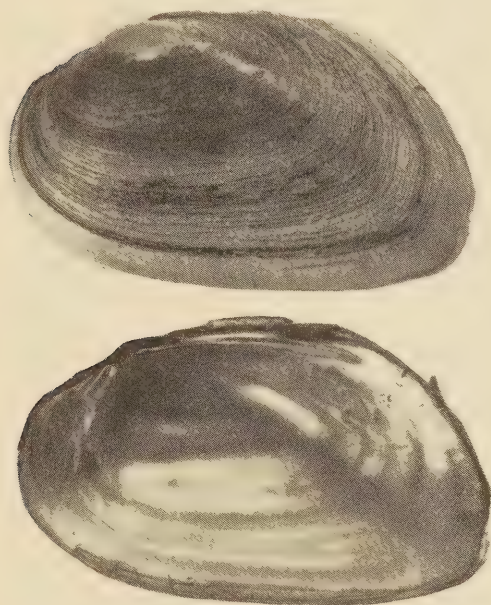


Figure 13. Lateral views of a shell of the File Spike, a taxonomically indeterminate member of the genus *Elliptio*. Lake Waccamaw, Columbus County. Actual length 39 mm. Note the well developed, rather evenly spaced periostracal ridges, which lend this morph its vernacular name.

References: Fuller, S. L. H. 1971. A brief field guide to the fresh-water mussels (Mollusca: Bivalvia: Unionacea) of the Savannah River system. ASB Bull. 18:137-146.

Ligumia nasuta (Say)

EASTERN POND MUSSEL

Remarks: The name "Pond Mussel" is widely used for *Ligumia subrostrata* (Say) of the Mississippi basin and western Gulf drainages. It is equally appropriate for the Atlantic drainage taxon, *L. nasuta*. The two nominal species are often considered conspecific, but, now that Bereza et al. (1976) have demonstrated soft-tissue discriminations between them, it has become practical to entertain two vernacular names, the Western and Eastern Pondmussels, respectively. Johnson (1970) recorded the eastern species from the Great Lakes and St. Lawrence River system southward into the James River system of Virginia, but, on the basis of soft-tissue evidence, M. J. Imlay and S. L. H. Fuller verified R. M. Shelley's (pers. comm.) record of shells of *L. nasuta* from the tidal Chowan River near Eure, Gates County, North Carolina. Because this is the only record of this species from the state, and because it is also very likely to be more widespread, it is reasonably considered as of *Undetermined* status. Further records may be forthcoming only slowly because the Eastern Pondmussel is easily confused with certain morphs in the group of *Elliptio lanceolata* (Figure 12). Separation, however, is facilitated by the strongly pigmented and weakly papillose postbasal mantle margin of *Ligumia*, as opposed to the absence of such features from *Elliptio* (compare Figures 13 and 18). Like the Tidewater Mucket and the Alewife Floater, the Eastern Pondmussel is a characteristic species of lower parts of river basins, including tidal regions, although it commonly occurs much farther upbasin than do these other two species (e.g., see Smith 1974). The presumption that such distribution does not indicate glochidial parasitism on an anadromous host fish is strengthened by the fact that Lefevre and Curtis (1912) recorded only certain non-migratory fishes of the family Centrarchidae as hosts for *L. subrostrata*. In spite of the Eastern Pondmussel's distributional success, it is seldom abundant, especially in fluviatile bodies of water. However, its habitat predilections are catholic. In addition to Johnson's (1970) illustrations, Emerson and Jacobson (1976) figured *L. nasuta* and added a common name, Nose Mussel, the reference being to the Latin *nasutus*, "having a large nose."

References: Emerson and Jacobson (1976), Johnson (1970); see list following introduction.

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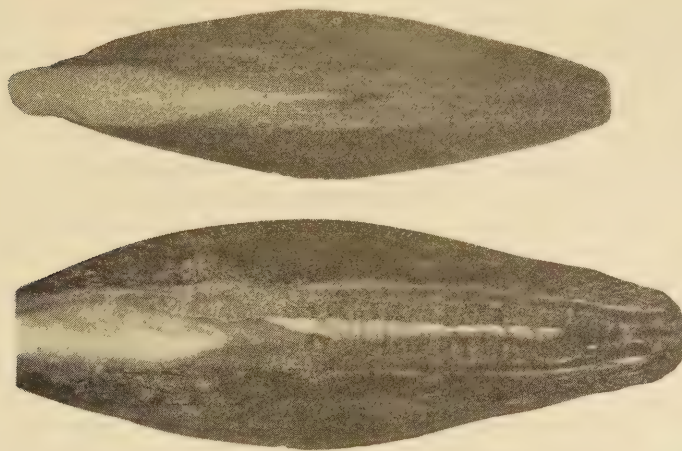


Figure 14. Ventral views showing the postbasal mantle margins of a male (above) and a female (below) Eastern Pondmussel, *Ligumia nasuta*, from the Chowan River, Gates County. Actual lengths ca. 90 mm. The whitish mass within the mantle cavity of the female is the charged marsupium of the left gill. Compare it, plus the broad, darkly pigmented, and papillose mantle margin (especially well developed in the female), to analogous aspects of other lampsilines (Figures 5, 6, and 12). Note, also, the absence of such features from even the conchologically similar members of the genus *Elliptio* (Figures 8 and 9).

Discussion

Frank Barick: I wonder if you would comment further on the nature of the factors that might adversely affect these mussels in the Cape Fear River, particularly, as well as the Tar. Would channel dredging operations have any effect on the critters?

Fuller: Yessir, all channel work of any kind whatsoever, no exceptions, will have adverse impact, not just on the mussels but on other benthos as well. Other problems that I didn't mention are associated, for instance, with dams, artificial tides, long term changes in water level -- irregular, unpredictable, violent oscillations, commonly -- cold water, anoxic water, and sedimentation problems which exist already because of agrarian practices. I could go on and on, in addition to the one or two that I alluded to during the course of the talk. I hope that responds to you adequately, for the moment.

Susan Bondurant: Could you tell me how, if anyone knows, the Chinese clam gets introduced into waters such as these? Or have there been any studies done on other times when the Chinese clam has come in and crowded out the indigenous species?

Fuller: There is very little, if any, direct evidence that the Chinese clam outcompetes the other critters there. There is a lot of circumstantial evidence to this effect, however. I don't know of any experimental evidence. There have been many studies done on the clam, but none of them has come to grips with either question that you raise. We don't know for sure how they are introduced. We have circumstantial evidence that suggests various things, but we do not know.

Bondurant: I'm sorry, I may be naming the slide wrong. But, I thought I heard you say that it has been known to crowd out indigenous species. This is the small, yellow one . . .

Fuller: Yes, I follow you. I tried not to be so positive about that. I intended to say "it is thought to" or "there is circumstantial evidence that". If I spoke more positively that was a mistake on my part.

Bondurant: Well, the reason for my question -- I was thinking it would be a smart developer that put a couple down in a lake, to get rid of some of our . . .

Fuller: Well, yeah, yeah, that's a fiendish possibility. May even be true. He could have got them at 'most any aquaria shop. They are being, unfortunately, widely disseminated in the aquarium trade. That's one way they get around.

Ed Menhinick: With the interest in control of *Corbicula*, would it perhaps be worthwhile to study its ecology in its native land, with particular regard to population control in hopes that some predator or something might be discovered?

Fuller: I think that would be wonderful. There are two objections to that idea. Number one, we're not absolutely sure of what its native land is. It wound up on the west coast in the '30's. First wild population was discovered on the west coast about 1938. It probably escaped from live food markets. We don't know that for sure, and we don't know where the first populations came from. We don't know that all *Corbicula* in this country are indeed *manilensis*. We are operating in the dark. Second problem is that if any of these fatherlands, one or more, are in the hands of Communist political systems, we're probably not going to get a chance to go in there and do very much research.

Jerry Deakle: How extensive is the problem with mollusks throughout eastern North Carolina with respect to the rivers and larger bodies of water?

Fuller: I would say that there's probably no single body of water anywhere in the United States that is not under some kind of adverse pressure owing to man's activities. I cannot speak for every single river system in this state, unfortunately. I haven't worked them all; I fear nobody has. The problems are more extensive, though, I guarantee you, than can be inferred from the few examples I've thrown up here on the screen, and my remarks about them. That's a rotten answer and I don't know -- you'd have to ask me more detailed questions, and I invite you to do so subsequently. Be happy to talk.

Tom Quay: Vince Bellis, you work in the freshwater systems of eastern North Carolina. You got any comment on that?

Vince Bellis: I was thinking of asking a question, because I know the Tar River. I'm a botanist; I was impressed by the fact that all these clams pretty much looked alike to me. And then I began to wonder -- we are planning on talking to our local legislator about some of these problems, and I was, in my mind, wracking my brain for a way to convince this legislator that these things are worth anything except that maybe the Indians ate them 200 years ago. Maybe, if you could, give us some advice as to what to say to this man.

Fuller: Hmmm. Well, we probably look pretty much alike to the clams. It's a matter of developing an oriented, experienced acuity of vision in this area. As you know perfectly well as a botanist, you can't imagine the mosaic that confronts me whenever I walk along a roadside. I can't . . . well, never mind, I'm not a botanist. Seriously, though, that is a very practical and pressing problem and I believe that this country needs to make these kinds of data, identities, concepts, part of public education from the ground up. I don't see any reason why it can't be done. We need better trained eyes, all of us. More specifically, law enforcement personnel are going to have to be radically educated. They're going to have to become, man and woman, as good as I am at picking these things up. They're going to have to, and it's not just clams. This would be true of all the creatures, fishes and plants and what not. Otherwise, we can pass thousands of laws and they're still going to keep slipping through our fingers down the tubes because nobody out there knows what to protect

and what not to. Another pretty generalized answer.

Bondurant: I have a specific comment, Vince, in reference to that. The same argument used awhile ago in regard to plants can be used with your legislator, being that, even though they may look alike, their secretions are different just as ours are different, and it may be one of these very mollusks' secretion that furnishes us the cure for cancer. Who knows? Throw that out to him and see what he says.

Marc Imlay: The fact is that mollusks rarely get cancer. They have already isolated a cancer-inhibiting drug from one genus.

Editor's Note: For a recent discussion of "cancers" in mollusks, see: Scarpelli, D. G., and A. Rosenfield (Eds.). 1976. Molluscan Pathology. Marine Fisheries Review 38(10):1-50. It is also pertinent to Dr. Imlay's comment that two United States institutions have recently committed a total of over \$116,000 for the study of an unidentified substance in the liver of clams which is known to retard tumor growth in mammals (Bio-Science. 1977. 23:229).

¹Rowland M. Shelley provided the following additional information on *Corbicula* which, unfortunately, could not be assembled until after the camera-ready copy had been completed: "*Corbicula manilensis* is known from the following North Carolina bodies of water: Lake Norman (Duke Power Co., pers. comm. from John S. Garton); Lake Wylie (Lemat, D. R., and C. M. Weiss. 1973. Distribution of benthic macroinvertebrates in Lake Wylie, North Carolina-South Carolina. Publ. No. 331 Dept. Environ. Sci. Engrg., Sch. Public Health, Univ. North Carolina, Chapel Hill, NC); Cape Fear River near crossing of NC hwy. 42 on Lee-Chatham Co. border near Corinth (Carolina Power & Light Co., pers. comm. from R. Hobbs); and a closed system cooling lake at the Louis V. Sutton Plant on US hwy. 421 north of Wilmington, New Hanover Co. (CP&L Co., pers. comm. from R. Hobbs). Thus, *Corbicula* is established in the Catawba, Cape Fear, and Waccamaw river systems. It was first discovered in Lake Norman three to four years ago and has since increased tremendously. Its presence in the Sutton Plant lake, which is close to the lower Cape Fear River, and in the river itself near Corinth, implies that it may occur in the entire Cape Fear River below NC highway 42."

Freshwater and Terrestrial Arthropods

Introduction

by

Tom Daggy

Eleven persons participated in the discussions of our Committee. A number of others had contributed information by correspondence. Martha Cooper reluctantly but very graciously served as our Recording Secretary. We had a discussion first of all of the key categories -- *Endangered*, *Threatened*, *Special Concern*, and *Undetermined* -- and the Committee found that the state of our knowledge of arthropods made the application of these terms extremely difficult. Talking to people on other committees later I found that they considered the terms satisfactory for other groups, but they didn't seem to serve our purposes quite as well.

We asked the various people in attendance to present their candidates for a place on our list. Fred Coyle spoke for spiders, Rowland Shelley for millipeds and the scorpion, Jim Cornell and Tom Daggy for beetles, Jim Greene for lepidoptera, Dave Stephan for several groups, Martha Cooper for crustacea, and Samuel Gifford, although not a member of the Committee, contributed considerable information on rare butterflies of the Hatteras area. In review of the 1973 Preliminary list, the Committee decided that a considerable number of species could very well be deleted, had been put on without sufficient information, and probably did not belong there, and a number more should be added.

Before our list is actually prepared, we'll have to correspond with a number of specialists who were not on hand for this meeting, particularly in the lepidoptera. And, of course, when the list is finished following this meeting it's not "finished" at all, it's just the first list which will have to be modified many times.

The Committee realizes that only a few of the groups of freshwater and terrestrial arthropods were considered. Many groups -- symphyla, pauropoda, protura, homoptera, hemiptera, most hymenoptera, psocoptera, and a lot of others -- were scarcely mentioned or considered because there was no one on hand, and we had found no one previously, to furnish information on them. So, there is a vast amount of material on arthropods that hasn't been touched at all.

The Committee members were in uniform agreement that the roughly 16,000 described species of arthropods known to occur in North Carolina offered a tremendous challenge, one that could be met at the present time only by attacking some of the best known groups. But, they were agreed that continued efforts would have to be made, and eventually might produce results commensurate with the size and importance of the group. It was apparent that extensive collecting and systematic work must be the basis for a better understanding of the status of species of arthropods.

Several suggestions were made concerning the directions of effort for the future, and these might be pertinent for other groups. Cornell urged that maps giving land use plans for the state be prepared and made available. The two important categories of land use to be considered would be, first, those that removed habitats from danger by establishing parks, preserves, or refuges, and secondly, land uses that would put habitats

Freshwater and Terrestrial Arthropods -- Introduction

into danger, such as housing and other developments, new lakes and reservoirs, lumbering, additions to agricultural lands, and so forth. If such maps could be made available, known ranges of various organisms could be compared with them and it would be a very useful method of determining threat to species. Clarence Styron suggested that some of this could be done by computerizing the data. Another suggestion was that a list be prepared of all the species of arthropods known from North Carolina type localities. Dave Stephan volunteered that he might have someone in a position to do this job.

The Committee decided that no arthropod species in the state is known to be in imminent prospect of extinction, and therefore none is known to be *Endangered*. Four species were judged *Threatened*, and sixty-two were considered of *Special Concern*. Of the *Threatened* species, three are crayfish. One of these is known only from burrows in the lawn of one residence in Greensboro. A second species is restricted to riffles in clear water in the New River and its tributaries. If the river is dammed, of course, the species probably would become extinct. The third crayfish species is known in North Carolina only from the canal at Lake Waccamaw, and, as has been pointed out, the area is being developed for housing, the canal is becoming silted, and the crayfish is certainly threatened. The fourth *Threatened* species is a blind apterous beetle known only from a few specimens found in the area of a new housing development near Monroe, North Carolina.

The category of species of *Special Concern* includes species with somewhat less restricted habitat, or habitats less threatened, or those that are excessively rare. In this category the Committee placed three more crayfishes, two blind amphipods, a terrestrial isopod, two spiders, a scorpion, a millipede, a dragonfly, two scorpionflies, four moths, three butterflies, a bee, two ants, a true fly, and about forty beetles. This list has been somewhat emended for publication. The scorpion was included in the list chiefly because it is the only species of scorpion known from the state, and it does have a very limited range in a few of the southwesternmost counties. It should be emphasized by repeating that the arthropods listed reflect more-or-less the expertise of the Committee and not the total number of species that may eventually be included in such a list.

Sixteen thousand arthropods have been recorded in the state, and it has been estimated that that's only a relatively small number, maybe half the final number, and there just isn't enough known about arthropods in North Carolina, or anywhere else, to be really sure of the status of more than a very, very few of them. This means that there has to be a tremendous amount of work done before even a preliminary list of any kind is prepared for all of them.

There were some areas of special interest that we felt deserved special work for various kinds of arthropods. One of them was Lake Waccamaw, and we're happy to reinforce what has been said by others about the lake as being a place where we really need to concentrate our efforts on preservation as well as study. Other areas include the New River, and the mountains generally, particularly the higher peaks where speciation is high and the ranges of species are very limited.

A Comment on Coleoptera
by
James F. Cornell, Jr.

About 3,500 species of beetles have been reported from North Carolina (Ashe and Cornell 1973; Brimley 1938; Cornell 1967, 1972; Wray 1967). Of these, fewer than 100 may be classified as even of *Special Concern*. There are no common names for these beetles, and none is here proposed. For at least eight species there is as yet not even a scientific name.

Two of the species treated in this chapter are considered *Threatened*, forty-one are of *Special Concern*, and nineteen are rare species of *Undetermined* status. The two species treated as *Threatened* occur, respectively, in an active housing development near Monroe, and along the New River in North Carolina. The beetles considered to be of *Special Concern* are endemic species, mostly montane, with localized, ecologically restricted distributions. Most of them are wingless and probably unable to invade new territory. The rare beetles of *Undetermined* status have wider distributions in the Southeast, but are so seldom collected that they could be presently restricted to North Carolina.

One California scarab beetle in the genus *Dichelonyx*, and one Pennsylvania lepidodirid in the genus *Catopocerus*, have previously been cited as probably extinct (Cornell 1971, Peck 1974), but none of the North Carolina species in these genera seems in any present danger (Cornell 1973). Some of the endemic moss and soil inhabiting beetles of the higher mountain peaks may be in imminent danger of natural, rather than man-induced, extinction along with the stands of Fraser's fir, *Abies fraseri*, in their type localities.

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A Comment on Crayfishes
by
Martha R. Cooper and John E. Cooper

The crayfish fauna of North Carolina, while not yet specifically summarized in print, is much better known than most other arthropod groups. This is in large part due to the collections gathered and studies conducted over many years by Dr. Horton H. Hobbs, Jr., at the U. S. National Museum, Smithsonian Institution. In reviewing the ostracod species that live commensally on North Carolina crayfishes, Hobbs and Peters (1977, p. 8) list a total of 27 crayfish species currently recognized from the state. Four of these are undescribed and, since that writing, at least two additional new species have been discovered. This brings North Carolina's total to 29 species, of which 7 are apparently endemic to the state.

At the meeting of the Group Committee on Freshwater and Terrestrial Arthropods for the November, 1975, Symposium, only 5 crayfish species were brought up for consideration. Three of these -- *Cambarus (Depressicambarus) catagius*, *C. (Hiaticambarus) chasmodactylus*, and *Procambarus (Ortmannicus) lepidodactylus* -- were designated as *Threatened*, because of extreme rarity and/or direct threats to a major portion of their habitats within the state. This number represents about 10% of the currently known fauna. Two others -- *Cambarus (Puncticambarus) reburus*, and *Oreconectes virginienensis* -- were designated as of *Special Concern* on the basis of a combination of restricted geographic and ecological distribution, and unusual scientific interest.

Future deliberations might result in a somewhat revised list of crayfishes of concern. For example, if the New River is protected from impoundment and from the resulting loss of riffle habitats, *C. (H.) chasmodactylus* could almost certainly be deleted from the *Threatened* list. On the other hand, the Committee was unaware of the significance (or in some cases the existence) of some additional species which might be considered in drawing up the list at a later date. We list below some examples of such species in the hope of encouraging efforts to monitor their status in the state and to ensure the continued health of their habitats where possible.

In addition to *P. (O.) lepidodactylus*, five species of *Procambarus* are either endemic to North Carolina's Coastal Plain or are shared with adjacent sections of this province in South Carolina. The distributions of three of these, *P. (O.) medialis*, *P. (O.) plumimanus*, and *P. (O.) pearsei*, are mapped in Hobbs (1975, p. 14), and that of the fourth, *P. (O.) ancylus* in Hobbs (1959, p. 73, as "Species D"). The fifth, *P. (O.) blandingii*, occurs in the PeeDee and Santee basins of South Carolina and southern North Carolina (Hobbs 1974). All of these species occur in a variety of habitats, primarily lentic (still or slow-moving waters), and should presumably be more adaptable to disturbances of local areas than are less tolerant species.

At the other end of the state, in the Blue Ridge province, are two crayfishes -- *Cambarus (Jugicambarus) nodosus* (Bouchard and Hobbs 1976), and an undescribed form mentioned as "*C. (Puncticambarus) sp. D*" by Hobbs and Peters (1977). In North Carolina both are found only in Cherokee County, and have rather restricted overall ranges including the Hiwassee River basin in adjacent Georgia and Tennessee.

Finally, mention should be made of a recently discovered species of *Orconectes* known at present from two tributaries of the Neuse River in Wake and Johnston counties, which is of considerable biogeographic interest. This species, currently under study by Martha R. Cooper and Horton H. Hobbs, Jr., is most closely related to species occurring in central Tennessee and Kentucky and in the Ozark region. It is only the third, and southernmost, species of *Orconectes* recorded from anywhere on the Atlantic seaboard.

The crayfish Species Accounts in this chapter include brief descriptions of superficial features which may distinguish the species from others in the same region, but which should not be relied on for conclusive determinations. Precise identification of crayfishes is generally based on the shape and structure of the first pleopod or "gonopod" of sexually mature (Form I or first form) males, and other morphological characters. This usually requires the use of detailed keys, and references to such keys are included in the Accounts. The terms used in the descriptions below are illustrated by Hobbs (1972, pp. 8-9) and in several other review publications on crayfishes. Figure 1 (below) illustrates a few of them.

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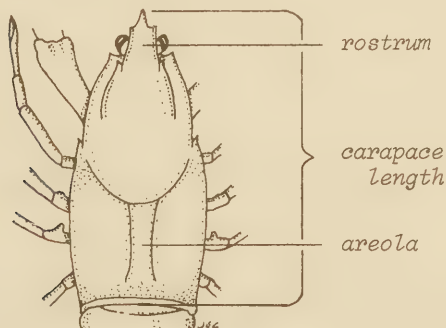


Figure 1. Dorsal view of anterior of a crayfish, showing rostrum, areola, and carapace length.

Freshwater and Terrestrial Arthropods -- Species List

Species List

Species	Status
Arachnida	
Scorpionida	
Vejovidae	
<i>Vejovis carolinianus</i> , Carolina Scorpion 209	Special Concern
Araneae	
Dipluridae	
<i>Microhexura montivaga</i> , North Carolina	
Funnelweb Tarantula 210	Special Concern
Linyphiidae	
<i>Ivesia carolinensis</i> , Linville Caverns Spider 211	Special Concern
Crustacea	
Isopoda	
Trichoniscidae	
<i>Miktoniscus alabamensis</i> , Small Alabama Sowbug 211	Special Concern
Amphipoda	
Gammaridae	
<i>Stygobromus</i> sp. A 212	Special Concern
<i>Stygobromus</i> sp. B 212	Special Concern
Decapoda	
Cambaridae	
<i>Cambarus (Depressicambarus) catagius</i> , Greensboro	
Burrowing Crayfish 203	Threatened
<i>Cambarus (Hiaticambarus) chasmodactylus</i> , New	
River Riffle Crayfish 204	Threatened
<i>Cambarus (Puncticambarus) reburus</i> , French	
Broad Stream Crayfish 213	Special Concern
<i>Orconectes virginienensis</i> , Chowan River	
Crayfish 214	Special Concern
<i>Procambarus (Ortmannicus) lepidodactylus</i> ,	
PeeDee Lotic Crayfish 206	Threatened
Diplopoda	
Polydesmoidea	
Xystodesmidae	
<i>Dixioria dactylifera</i> 216	Special Concern
Insecta	
Odonata	
Petaluridae	
<i>Tachopteryx thoreyi</i> , Thorey's Grayback 216	Special Concern
Mecoptera	
Meropeidae	
<i>Merope tuber</i> , Earwigfly or American Earwigfly	Special Concern
217	

Freshwater and Terrestrial Arthropods -- Species List

Insecta

Mecoptera

Panorpidae

- | | |
|--|-----------------|
| <i>Brachypanorpa carolinensis</i> , Shortnosed | |
| Scorpionfly 218 | Special Concern |

Lepidoptera

Lycaenidae

- | | |
|--|-----------------|
| <i>Callophrys</i> (=Mitoura) <i>hesseli</i> , Hessel's | |
| Hairstreak 219 | Special Concern |

Hesperiidae

- | | |
|--|-----------------|
| <i>Problema bulenta</i> , Rare Skipper 220 | Special Concern |
|--|-----------------|

Coleoptera

Cicindelidae

- | | |
|--------------------------------------|-----------------|
| <i>Cicindela ancocisconensis</i> 221 | Special Concern |
|--------------------------------------|-----------------|

Carabidae

- | | |
|--|-----------------|
| <i>Anillinus</i> n. sp. A 207 | Threatened |
| <i>Anillinus</i> n. sp. B 221 | Special Concern |
| <i>Anillinus</i> n. sp. C 221 | Special Concern |
| <i>Agonum</i> (<i>Platynidius</i>) <i>gracilentum</i> 226 | Undetermined |
| <i>Maronetus</i> n. sp. 221 | Special Concern |
| <i>Maronetus tenuis</i> 221 | Special Concern |
| <i>Maronetus unistriatus</i> 226 | Undetermined |
| <i>Nebria appalachia</i> 226 | Undetermined |
| <i>Pterostichus</i> (<i>Cylindrocharis</i>) <i>hypogea</i> 221 | Special Concern |
| <i>Pterostichus blanchardi</i> 226 | Undetermined |
| <i>Pterostichus carolinus carolinus</i> 226 | Undetermined |
| <i>Pterostichus carolinus fumorum</i> 226 | Undetermined |
| <i>Pterostichus</i> (<i>Gastrellarius</i>) <i>unicarum</i> 226 | Undetermined |
| <i>Pterostichus</i> (<i>Haplocoelus</i>) <i>primus</i> 226 | Undetermined |
| <i>Pterostichus lubricus</i> 226 | Undetermined |
| <i>Pterostichus manicus plethorus</i> 226 | Undetermined |
| <i>Pterostichus palmi</i> 226 | Undetermined |
| <i>Scaphinotus guyoti</i> 226 | Undetermined |
| <i>Scaphinotus violacea</i> 226 | Undetermined |
| <i>Stylulus</i> (?) n. sp. 221 | Special Concern |
| <i>Trechus balsamensis</i> 222 | Special Concern |
| <i>Trechus carolinae</i> 222 | Special Concern |
| <i>Trechus luculentus</i> 222 | Special Concern |
| <i>Trechus mitchellensis</i> 222 | Special Concern |
| <i>Trechus novaculosus</i> 222 | Special Concern |
| <i>Trechus rosenbergi</i> 222 | Special Concern |
| <i>Trechus satanicus</i> 222 | Special Concern |
| <i>Trechus subtilis</i> 222 | Special Concern |

Staphylinidae

- | | |
|--------------------------------|-----------------|
| <i>Lathrobium shermani</i> 222 | Special Concern |
|--------------------------------|-----------------|

Pselaphidae

- | | |
|------------------------------|-----------------|
| <i>Arianops alticola</i> 223 | Special Concern |
| <i>Arianops barbata</i> 223 | Special Concern |
| <i>Arianops coveeti</i> 223 | Special Concern |
| <i>Arianops fovealis</i> 223 | Special Concern |
| <i>Arianops gigantea</i> 223 | Special Concern |

Freshwater and Terrestrial Arthropods -- Species List

Pselaphidae		
<i>Arianops laminata</i>	223	Special Concern
<i>Arianops nantahalae nantahalae</i>	223	Special Concern
<i>Arianops nantahalae joanna</i>	223	Special Concern
<i>Arianops nodosa</i>	223	Special Concern
<i>Arianops norithe</i>	223	Special Concern
<i>Arianops parki</i>	223	Special Concern
<i>Arianops plectrops</i>	223	Special Concern
<i>Arianops spinicollis</i>	223	Special Concern
<i>Arianops teyahalee</i>	223	Special Concern
<i>Arianops thornei</i>	223	Special Concern
<i>Arianops uniconi</i>	223	Special Concern
<i>Ctenisius sp.</i>	227	Undetermined
<i>Mayetia sp. A</i>	223	Special Concern
<i>Mayetia sp. B</i>	223	Special Concern
<i>Mayetia sp. C</i>	223	Special Concern
<i>Mayetia bulla</i>	223	Special Concern
<i>Mayetia pearsei</i>		Special Concern
<i>Pilopius sp.</i>	227	Undetermined
Leptodiridae		
<i>Adelopsis mitchellensis</i>	224	Special Concern
Leiodidae		
<i>Agathidium n. sp.</i>	224	Special Concern
Limulodidae		
<i>Limulodes paradoxus</i>	227	Undetermined
Histeridae		
<i>Hetaerius sp.</i>	227	Undetermined
Scarabaeidae		
<i>Lichnanthe (=Amphicoma) vulpina</i>	228	Undetermined
<i>Psilocnemis leucosticta</i>	228	Undetermined
Elmidae		
<i>Stenelmis gammoni</i>	208	Threatened
Colydiidae		
<i>Aglenus brunneus</i>	228	Undetermined
Hymenoptera		
Formicidae		
<i>Amblyopone trigonignatha</i>	229	Undetermined
<i>Formica exsectoides</i> , Alleghany Mound Ant	224	Special Concern

SPECIES ACCOUNTS

CRUSTACEA; DECAPODA; CAMBARIDAE
(Cambarid Crayfishes)

Cambarus (Depressicambarus) catagius Hobbs and Perkins GREENSBORO
BURROWING CRAYFISH

Description: The Greensboro Burrowing Crayfish is a generally dark brown animal. Its chelae are greenish tan above and pinkish below, with orange finger tips. Carapace length of adults is commonly around 30 mm (1 1/8 in.) and total length around 55 mm (2 1/8 in.). Like other members of the subgenus *Depressicambarus*, the chelae are triangular in appearance, with the palms relatively broad and flattened. The areola is long and narrow, comprising 37 to 40% of the carapace length, and its length is some 17 to 23 times its width. As in most members of the genus, the first pleopod of males has two terminal elements recurved at nearly right angles to the main shaft. Of the two related species found in North Carolina's Piedmont, *C. (D.) latimanus* has a wider areola, with its length less than 12 times its width, and form-I males of *C. (D.) reduncus* may easily be distinguished by the long, extremely recurved terminal element of the first pleopod. Diagnostic illustrations for *C. (D.) catagius* are provided by Hobbs and Perkins (1967), and by Hobbs (1974, p. 89). Keys are given in Hobbs (1969, p. 104; 1972, p. 112).

Distribution: Range -- North Carolina endemic. Known only from type locality, lawn at East Whittington St. in southeastern area of Greensboro, Guilford Co. (Cape Fear River drainage). Hobbs (1969, p. 137) includes distribution map for subgenus, showing this species on an edge of the subgeneric range.

Habitat and Mode of Life: Very little is known about this crayfish, but it is apparently a primary burrower (i.e., largely or entirely restricted to burrows rather than living in surface waters). Members of the species construct complex, branching burrows in "a sandy-clay soil in which the water table varies from a few inches to two feet below the surface of the ground" (Hobbs and Perkins 1967). The only known locality is in a rolling terrain about 150 m (490 ft.) from the nearest creek.

Reproduction: Specimens have been collected only in months from February through June, and during this period breeding males greatly outnumbered form-II males. A single female carrying eggs was found in June (Hobbs and Perkins 1967).

Status: *Threatened*. No attempts to determine the current condition of the one known population, or expressly to seek out additional populations, have been made. Nevertheless, a good number of crayfish collections have been made over the years from burrows in the North Carolina Piedmont, and apparently none of them contain this species. More concerted research efforts to find and disinter primary burrowers in the area could possibly reveal the existence of other populations and a wider geographic range. From the information presently available, however, the restriction of the

species to a single locality, much of which "has been cut over and has been converted to lawns and gardens" (Hobbs and Perkins 1967) would at least appear to place the species in jeopardy.

Remarks: The vernacular name Greensboro Burrowing Crayfish, designated here, derives from the only known site of occurrence and from the fact that the species is a primary burrower known from no other habitat. The type locality of the crayfish is also the type locality for two species of entocytherid ostracods which live as commensals on the crayfish. However, both species (*Entocythere dentata* Crawford and *Ankylocythere ancyla* Crawford) occur on many other crayfishes and are more widely distributed than is *C. catagius* (Hobbs and Peters 1977).

- References: Hobbs, H. H., Jr. 1969. On the distribution and phylogeny of the crayfish genus *Cambarus*. In: P. C. Holt (Ed.). The Distributional History of the Biota of the Southern Appalachians. Part I: Invertebrates. Res. Div. Monogr. No. 1, Va. Polytech. Inst. State Univ., Blacksburg, VA:93-178.
- Hobbs, H. H., Jr. 1972. Crayfishes (Astacidae) of North and Middle America. Biota of Freshwater Ecosystems, Ident. Man. No. 9. Environ. Protect. Agency, Washington, DC. 173 pages.
- _____. 1974. A checklist of the North and Middle American crayfishes (Decapoda: Astacidae and Cambaridae). Smithson. Contr. Zool. No. 166, Washington, DC. 161 pages.
- _____, and F. O. Perkins. 1967. A new burrowing crayfish from North Carolina (Decapoda, Astacidae). Proc. Biol. Soc. Wash. 80:141-146.
- _____, and D. J. Peters. 1977. The entocytherid ostracods of North Carolina. Smithson. Contr. Zool. No. 247, Washington, DC. 73 pages.

Authors: Martha R. Cooper and John E. Cooper.

Cambarus (Hiaticambarus) chasmodactylus James

NEW RIVER RIFFLE
CRAYFISH

Description: This is a relatively large crayfish, with carapace lengths ranging from 30 to 55 mm (1 1/8 to 2 1/8 in.) and total body lengths of about 60 to 95 mm (2 3/8 to 3 1/4 in.) in adults. The impression of even larger size is enhanced, particularly in breeding males, by the very large chelae, which are commonly much longer than the carapace. The chelae of at least one individual reached a length of 78 mm (over 3 in.). As in other members of the subgenus the chelae are further distinctive in having smooth surfaces, almost lacking the ridges and tubercles common to most crayfishes, and in the often enormous gape or space between the fingers for most of their length. Overall body color is "concolorous blue green tinged with shades of cream to rust" (James 1966). The areola is broad (length about 4 to 6 times width) and densely studded with punctations, and the rostral margins are smooth with no spines or tubercles. As in most members of the genus, the first pleopod of males has two terminal elements recurved at nearly right angles to the main shaft. *Cambarus (H.) chasmodactylus* differs from *C. (H.) longulus*, which inhabits the adjacent Yadkin River drainage, in having relatively longer fingers on the chela, with the movable finger being more than

twice as long as the mesial margin of the palm. Keys precisely distinguishing the New River Riffle Crayfish from other members of the subgenus are provided by Hobbs (1969, p. 106; 1972, p. 120). Diagnostic illustrations for the species are in James (1966, p. 15 and Plate 1) and Hobbs (1974, p. 92).

Distribution: Range -- endemic in New River drainage system, from upper reaches of Greenbrier River, Pocahontas Co., West Virginia, south through Virginia to headwaters of South Fork New River, Watauga Co., North Carolina (maps in James 1966, p. 13, and Hobbs 1969, p. 140).

North Carolina -- New River system, in Alleghany, Ashe, and Watauga cos.

Habitat and Mode of Life: The members of this subgenus, more than any other crayfishes, are limited in their ecological distribution to unsilted streams having rock-strewn riffle areas (Hobbs 1969). Individuals "live under or between rocks, away from the shore, in moderate to swiftly flowing, cool to cold water," and "do not ... frequent quiet pools, springs, or mountain 'feeder brooks'" (James 1966). *C. (H.) chasmodactylus* in particular seems to require larger, often turbulent streams.

Reproduction: While there are no published reproductive data for this species itself, the general patterns might be expected to parallel those of its relative, *C. (H.) longulus*, which occurs in drainages immediately east of the New River. Smart (1962) found that this species, in a tributary of the James River, has rather well-defined reproductive cycles. Eggs are laid from late April to mid-July, hatching in about three weeks. Sexual maturity is attained in 16 to 17 months, and copulation occurs from September to April. Adults apparently survive through two breeding seasons, with a longevity of 36 or 37 months. Females produce relatively few eggs each season, with a maximum of 45 observed attached to any individual. Since *C. (H.) chasmodactylus* usually frequents larger streams than does *C. (H.) longulus*, its reproductive cycles might possibly be somewhat less well defined, although there is currently no evidence that this is true.

Status: *Threatened*. This species is a New River endemic which requires lotic waters of considerable size. Although it is now often common within its range, impoundment of these moving waters would eliminate the riffle habitat required by the species. Thus, it would almost certainly be eliminated from all areas converted to lentic habitats. Survival of the species in North Carolina might be possible in unimpounded headwater streams of South Fork, but it would certainly be rendered tenuous by isolation from remaining populations elsewhere. Furthermore, its apparent preference for larger streams could prevent its establishment in smaller headwaters. Preservation of the North Carolina populations of the species is given added importance by the already limited availability of appropriate habitat in the Virginia and West Virginia portions of its range, and by other apparent encroachments on the few known populations in those states.

Remarks: This species was originally described as a subspecies of *Cambarus longulus*.

References: Hobbs, H. H., Jr. 1969. On the distribution and phylogeny of the crayfish genus *Cambarus*. In: P. C. Holt (Ed.). The Distributional History of the Biota of the Southern Appalachians. Part I: Invertebrates. Res. Div. Monogr. No. 1, Va. Polytech. Inst. State Univ., Blacksburg, VA:93-178.

Hobbs, H. H., Jr. 1972. Crayfishes (Astacidae) of North and Middle America. Biota of Freshwater Ecosystems, Ident. Man. No. 9. Environ. Protect. Agency, Washington, DC. 173 pages.

_____. 1974. A checklist of the North and Middle American crayfishes (Decapoda: Astacidae and Cambaridae). Smithson. Contr. Zool. No. 166, Washington, DC. 161 pages.

James, H. A. 1966. Range and variations of subspecies of *Cambarus longulus* (Decapoda: Astacidae). Proc. U. S. Nat. Mus. 119:1-24.

Smart, G. C., Jr. 1962. The life history of the crayfish *Cambarus longulus longulus*. Amer. Midl. Nat. 68(1):83-94.

Authors: Martha R. Cooper and John E. Cooper.

Procambarus (Ortmannicus) lepidodaetylus Hobbs PEEDEE LOTIC CRAYFISH

Description: The Pee Dee Lotic Crayfish is a small to moderate sized animal, in which adult carapace lengths reach about 25 mm (1 in.) and total lengths about 55 mm (2 1/8 in.). It has large eyes and relatively small chelae, which is typical of most members of the genus in this area. The basic color is tan or greenish tan, and the abdomen is generally paler than the carapace except for a darker crossband at the posterior margin of each segment, and a heavy blackish blotch on the sides of each segment. There is a narrow, horizontal, dark bar across the posterior margin of the carapace. One superficial feature which may aid in identification is the long, tapering rostrum with its small marginal spines. Another and more significant feature is the short, broad areola, which comprises just 28 to 29% of the carapace length and has its length only about 3 to 5 times its width. Like most members of the genus, conclusive identification of *P. (O.) lepidodaetylus* is based largely on the configuration of the first pleopod of form-I males. Diagnostic illustrations are provided in Hobbs (1947, p. 30; 1974, p. 135), and keys for identification are in Hobbs (1968, 1972).

Distribution: Range -- tributaries of Pee Dee, Black, and Wateree rivers in lower Piedmont and Coastal Plain of NE South Carolina, and in extreme SE North Carolina (map in Hobbs 1958, p. 72).

North Carolina -- only one definite site, canal off Waccamaw River, apparently 7.5 air mi. south of Lake Waccamaw, Columbus Co. (1949).

Habitat and Mode of Life: This species occurs in swift, clear, small-to-medium sized, sand-bottomed streams flowing through swampy areas. The crayfish are sometimes found in the roots of plants along the banks. Nothing has been published on reproduction or other aspects of the natural history of the species.

Status: *Threatened*. The extremely limited known occurrence of this species in the state, coupled with the rapid development occurring in the general vicinity of Lake Waccamaw, gives ample cause to assign it this status. Because of its occurrence in other parts of the PeeDee drainage in South Carolina, the species may yet be discovered in tributaries of the Lumber River of North Carolina, including in the Robeson County area. This might reduce its status in the future, but because of its requirement for clear lotic habitats, and the limited occurrence of such habitats in the Coastal Plain of the state, the species should probably always be given some concern to assure its preservation.

Remarks: *Procambarus (O.) lepidodactylus* in North Carolina is of special biogeographic interest as the northernmost occurrence of any member of the entire Pictus Group of the subgenus *Ortmannicus*. Other species in the group are found in lotic habitats along the Atlantic coast south to Florida.

References: Hobbs, H. H., Jr. 1947. A key to the crayfishes of the Pictus Subgroup of the genus *Procambarus*, with the description of a new species from South Carolina. Fla. Entomologist 30(3):25-31.
Hobbs, H. H., Jr. 1958. The evolutionary history of the Pictus Group of the crayfish genus *Procambarus* (Decapoda, Astacidae). Quart. J. Fla. Acad. Sci. 21(1):71-91.
_____. 1968. Crustacea: Malacostraca. In: F. K. Parrish. Keys to Water Quality Indicative Organisms (Southeastern United States). Federal Water Poll. Control Admin., Dept. Interior, Washington, DC:K1-K36.
_____. 1972. Crayfishes (Astacidae) of North and Middle America. Biota of Freshwater Ecosystems, Ident. Man. No. 9, Environ. Protect. Agency, Washington, DC. 173 pages.
_____. 1974. A checklist of the North and Middle American crayfishes (Decapoda: Astacidae and Cambaridae). Smithson. Contrib. Zool. No. 166, Washington, DC. 161 pages.

Authors: Martha R. Cooper and John E. Cooper.

INSECTA; COLEOPTERA; CARABIDAE
(Ground Beetles)

Anillinus n. sp. A

Description: This undescribed soil-inhabiting beetle is very small, attaining a length of 2 mm, and is eyeless, wingless, and depigmented. It is characterized and differentiated from related species by certain features of the male aedeagus (genitalia). See Jeannel (1963) for related species.

Distribution: Range -- North Carolina endemic, known only from woods litter in a housing development 4.8 km (3 mi.) W Monroe, Union Co.

Habitat and Mode of Life: These beetles are typically found in litter or soil in moist mesic woods. The three specimens seen were from a stump-hole and under a log in a mixed deciduous woods bordering a small stream.

Status: *Threatened*. Further development is occurring in the area where this new species is found, and no protective measures are currently in force. It is presently represented by three specimens collected in 1973 in the J. F. Cornell Coleoptera Collection. Since it occurs on the flood-plain of a small stream, the most effective protection may be to limit channelization of the stream and major destruction of the adjacent woods.

Remarks: Although this is an insignificant animal with no known commercial, social, or recreational value, and little scientific value, knowing more about the species/population could be of value in assessing man's impact on similar species in precarious situations. Support should be given to additional research while the population is apparently healthy, and the species should be described.

References: Cornell, J. F., Jr. 1972. The eyeless beetles of North Carolina with notes on their ecology and evolution. J. Elisha Mitchell Sci. Soc. 88(4):260-264.
Cornell, J. F., Jr. 1973. The endangered beetle species list: progress and problems. J. Elisha Mitchell Sci. Soc. 89(4):250.
Jeannel, R. 1963. Supplément a la monographie des Anillini: sur quelques espèces de l'Amerique du Nord. Revue Francaise d'Entomol. 30:145-172.

Author: James F. Cornell, Jr.

INSECTA; COLEOPTERA; ELMIDAE
(Drive or Riffle Beetles)

Stenelmis gammoni White and Brown

Description: This is a small, aquatic beetle, measuring 2.3 to 2.4 mm in length, with dark brown to black elytra (wing covers) which are bimaculate. It differs from the related *S. numerosa* Mots. in having darker antennae and palpi, bimaculate elytra, and in details of the male genitalia. See White and Brown (1976).

Distribution: Range -- North Carolina endemic, known from South Fork New River, Ashe Co.

Habitat and Mode of Life: The larvae and adults of this beetle are aquatic, preferring highly oxygenated, moving water.

Status: *Threatened*. This species is locally abundant (about 1,100 specimens were examined by White and Brown), but could be jeopardized by those changes in water quality in the New River and its tributaries which

would undoubtedly occur if the river is dammed.

Remarks: Although of no known commercial or social value, the species may have scientific utility as an indicator of water quality.

Reference: White, D. S., and H. P. Brown. 1976. A new species of *Stenelmis* from North Carolina (Coleoptera: Elmidae). *Coleopterist's Bull.* 30(2):189-191.

Author: James F. Cornell, Jr.

All of the following species are of *Special Concern*. Complete accounts are provided for some of them, and annotated lists for others. Most, especially the beetles, have no vernacular names. Several authors have coined common names for this volume, but these are not necessarily to be considered formal proposals.

ARACHNIDA; SCORPIONIDA; VEJOVIDAE
(Scorpions)

Vejovis carolinianus (Beauvois)
(= *V. carolinus*)

CAROLINA SCORPION OR
SOUTHERN UNSTRIPED SCORPION

Description: A scorpion which attains a total length of around 25 mm (1 in.), excluding the tail (metasoma). It is uniformly dark brown dorsally, without stripes. The venter is considerably lighter, and the pectines (comb-like structures) are pale yellow. The sting is without a tubercle (spur) at its base. This species can be distinguished from other southeastern scorpions by the uniformly colored dorsum and absence of the spur. Photographs are available in Muma (1967) and Shelley (1975a, b).

Distribution: Range -- Texas to North Carolina and Kentucky.
North Carolina -- lower elevations, under 600 m (2,000 ft.) in border counties of southwest; known authentically from Cherokee, Transylvania, and Polk cos., but probably in intervening areas. May extend up river valleys, but doubtful at higher elevations.

Habitat and Mode of Life: This scorpion is found under rocks, logs, and other shelter during the day, but ventures forth nocturnally. It has been collected around construction sites near Tryon, Polk County.

Status: *Special Concern.* *Vejovis carolinianus* is significant in being the only scorpion native to North Carolina. It appears to have a discontinuous distribution in the northern part of the overall range, and every effort should be made to convey sight records and specimens to competent invertebrate zoologists.

Remarks: There is no evidence that the Carolina Scorpion is harmful

to man. Nevertheless, it can sting and should be treated with caution (Shelley 1975b).

- References: Muma, M. H. 1967. Scorpions, whip scorpions, and wind scorpions of Florida. *Arthropods of Florida and Neighboring Land Areas* 4:1-38.
- Shelley, R. M. 1975a. Occurrence of the scorpion *Vejois carolinianus* (Beauvois) in North Carolina (Arachnida: Scorpionida: Vejovidae). *J. Elisha Mitchell Sci. Soc.* 91:29-30.
- _____. 1975b. North Carolina's scorpion. *Wildl. in N. C.* 39(2): 8-9.

Author: Rowland M. Shelley.

ARACHNIDA; ARANEAE; DIPLURIDAE
(Funnelweb Tarantulas)

Microhexura montivaga (Crosby and Bishop)

NORTH CAROLINA
FUNNELWEB TARANTULA

Description: A tiny species, about 3 mm long, with a posterior pair of spinnerets half as long as the abdomen. The cephalothorax and legs are yellow-gray, and the abdomen is light red-brown. For illustrations and other identification aids see Chamberlin and Ivie (1945) and Crosby and Bishop (1925).

Distribution: Range -- North Carolina endemic, possibly restricted to type locality in spruce-fir forest on Mt. Mitchell, Yancey Co.

Habitat and Mode of Life: Little is known of the natural history of this spider, other than that it occurs in moss in spruce-fir forests.

Status: *Special Concern*. *Microhexura montivaga* is a relict species in both the evolutionary and zoogeographic sense of the word, and of considerable scientific interest. It is the only member of the primitive mygalomorph family Dipluridae found east of the Mississippi River, and there are only two other species in its genus anywhere in the world (in the Pacific Northwest). It has been specifically sought by the author and Dr. William A. Shear on a number of occasions at the type locality, and in similar North Carolina mountain habitats to the north and south, but never found. It may well merit the status of *Endangered* or *Threatened*, but only further research will settle this question.

References: Chamberlin, R. V., and W. Ivie. 1945. On some nearctic mygalomorph spiders. *Ann. Entomol. Soc. Amer.* 38:549-558.

Crosby, C. R., and S. C. Bishop. 1925. Two new spiders from the Blue Ridge Mountains of North Carolina. *Entomol. News* 36:142-146.

Author: Frederick A. Coyle.

Freshwater and Terrestrial Arthropods -- Special Concern

ARACHNIDA; ARANEAE; LINYPHIIDAE
(Sheetweb Spiders)

Ivesia carolinensis Bishop

LINVILLE CAVERNS SPIDER

Description: A small spider, about 3 to 5 mm long, with yellow legs and cephalothorax and dirty white abdomen. Illustrations and other identification aids are provided in Bishop (1950).

Distribution: Range -- North Carolina endemic, known only from Linville Caverns, near Linville Falls, McDowell Co.

Habitat and Mode of Life: The reduced anterior median eyes, pale color, and site of collection ("wall of cave a short distance from the entrance") of the only known specimens indicate that this spider is a cave dweller. Nothing else is known of its natural history.

Status: *Special Concern*. This is one of only two known species of *Ivesia* in the United States (the other occurs in a Tennessee cave), and its apparent rarity and very restricted range are the reasons for assigning it this status. It appears not to have been collected since its description in 1950, when one male and one female were taken, and further field work is required to learn more of its distribution and habits.

Reference: Bishop, S. C. 1950. A new cave spider from North Carolina. Proc. Biol. Soc. Wash. 63:9-12.

Author: Frederick A. Coyle.

CRUSTACEA; ISOPODA; TRICHONISCIDAE
(Trichoniscid Isopods)

Miktoniscus alabamensis Muchmore

SMALL ALABAMA SOWBUG

Description: This is a small, pigmented, terrestrial isopod, attaining a total length of about 5 mm. The body is flattened and rather narrow, and the head and most segments are tuberculate. There are seven pairs of legs. Specific identification of oniscoidean isopods requires dissection, differential staining, and microscopic examination of various structures. Diagnostic illustrations for this species are found in Schultz (1964), and Muchmore (1964) provides its formal description and distinguishes it from *M. linearis*.

Distribution: Range -- "Virginia southwestward to Alabama and Florida" (Holsinger and Peck 1971).

North Carolina -- Linville Caverns, McDowell Co.
(Schultz 1964, as *M. linearis*).

Habitat and Mode of Life: These kinds of isopods live in very moist

but not aquatic habitats, generally in leaf mold and wet detritus. Nothing is known of the natural history of the Small Alabama Sowbug in North Carolina. At its type locality, Shelta Cave, Alabama, it is most abundant in February, and is almost always found in and on decaying wood, although concentrations have been seen on animal scats and dead bats (J. E. Cooper, unpublished observations).

Status: *Special Concern.* The apparent rarity and very restricted range of this species in North Carolina are the reasons for assigning it this status. The three known North Carolina specimens, a male and two females, were collected in June, 1963. This widely distributed species is not cave limited in other parts of its range, however, and it is highly likely that intensive collecting for the species in the western part of the state will show its occurrence in other moist habitats outside caves here as well.

Remarks: Although there are many different kinds, terrestrial isopods in general are indiscriminately known as pillbugs, sowbugs, and wood lice.

References: Holsinger, J. R., and S. B. Peck. 1971. The invertebrate cave fauna of Georgia. NSS Bull. 33(1):23-44.
Muchmore, W. B. 1964. New terrestrial isopods of the genus *Miktoniscus* from eastern United States (Crustacea: Isopoda: Oniscoidea). Ohio J. Sci. 64(1):51-57.
Schultz, G. A. 1964. Two additional data on terrestrial isopod crustaceans: *Ligidium blueridgensis*, sp. nov., from Georgia and a North Carolina cave location for *Miktoniscus linearis* (Patience, 1908). J. Elisha Mitchell Sci. Soc. 80(2):90-94.

Authors: John E. Cooper and Martha R. Cooper.

CRUSTACEA; AMPHIPODA; GAMMARIDAE
(Gammarid Amphipods)

Stygobromus sp. A and *Stygobromus* sp. B

Description: Amphipods are small (2 to 30 mm), laterally compressed crustaceans with seven pairs of thoracic appendages, the first (anterior) two pairs of which are "clawlike" and known as gnathopods. Holsinger (1972) provides general information on collecting, preserving, and identifying gammaridean amphipods. The genus *Stygobromus* consists exclusively of subterranean forms which are white and eyeless. It has not previously been reported from North Carolina. A paper containing the formal description of *Stygobromus* sp. A has been accepted for publication (Holsinger, in press).

Distribution: Range -- both species are North Carolina endemics. Species A known from west side NC hwy. 128, ca. 2.5 km (1.5 mi.) north

Freshwater and Terrestrial Arthropods -- Special Concern

of Blue Ridge Pkwy., Yancey Co.; Species B known from 1,500 m (5,000 ft.) elevation below Mt. Lyn Lowrey (Jones Knob), Plott Balsam Mts., Jackson Co.

Habitat and Mode of Life: These amphipods inhabit groundwater, and the only known specimens of both were collected from seeps. Nothing is known of their natural history.

Status: *Special Concern*. The fact that these amphipods are known from but a single locality each, and their apparent rarity (only one specimen of Species B has been collected), are the reasons for their assignment to this status. Localized groundwater pollution could be a serious threat to both. Species B was listed as *Endangered* in the preliminary North Carolina report (DNER 1973), but no immediate threat to either of these amphipods can currently be identified.

References: DNER. 1973. Preliminary list of endangered plant and animal species in North Carolina. N. C. Dept. Nat. Econ. Resources, Raleigh, NC. 27 pages.

Holsinger, J. R. 1969. Biogeography of the freshwater amphipod crustaceans (Gammaridae) of the central and southern Appalachians. In: P. C. Holt (Ed.). The Distributional History of the Biota of the Southern Appalachians. Part I: Invertebrates. Res. Div. Monogr. 1, Va. Polytech. Inst. State Univ., Blacksburg, VA:19-50.

_____. 1972. The freshwater amphipod crustaceans (Gammaridae) of North America. Biota of Freshwater Ecosystems, Ident. Man. No. 5. Environ. Protect. Agency, Washington, DC. 89 pages.

_____. In press. Systematics of the subterranean amphipod genus *Stygobromus* (Crangonyctidae), Part II: Species of the Appalachian and Coastal Plain region of the eastern United States. Smithson. Contr. Zool.

Authors: John R. Holsinger and John E. Cooper.

CRUSTACEA; DECAPODA; CAMBARIDAE
(Cambarid Crayfishes)

Cambarus (Puncticambarus) reburus Prins FRENCH BROAD STREAM CRAYFISH

Description: This is a moderate-sized crayfish, with recorded adult carapace lengths of about 23 to 28 mm (around 1 in.) and reaching a total length just over 61 mm (2 3/8 in.). The species may be recognized among crayfishes of western North Carolina by the following combination of characters: a long, tapering rostrum without marginal spines; a broad areola with length only about 2 or 3 times its width; and, most significantly, long, subcylindrical chelae with very long palms (comprising at least a third of the length of the chela) and setose fingers. Color of living animals is olive brown, with dark brown dorsolateral crescents on each side of the carapace, continuing on the abdomen as stripes. The tips of the chelae are slightly orangeish (Prins 1968). As in other species of the

genus, the first pleopod of males has two terminal elements which are recurved at about right angles to the main shaft. Diagnostic illustrations are given by Prins (1968, p. 460) and by Hobbs (1974, p. 99), and a key is provided in Hobbs (1972).

Distribution: Range -- North Carolina endemic. Headwaters and tributaries of French Broad River; known from Buncombe, Henderson, and Transylvania cos. Single locality (the type locality) in headwaters of Savannah River system, a small tributary to Horsepasture River from impounded Saphire Lake E of Cashiers, Jackson Co., believed to be an introduced population (Prins and Hobbs 1972).

Habitat and Mode of Life: The species occurs in lotic habitats in headwater streams. Little else is known of its general natural history.

Reproduction: All 13 adult males collected in early April at the type locality were in breeding (form-I) stage and copulated readily in the collecting containers. Females with eggs were found in early May (Prins 1968). In all localities, form-I males have been found from November through July (Prins and Hobbs 1972).

Status: *Special Concern*. This species merits special attention to assure its survival since it is endemic to this restricted area of North Carolina, and because its dependence on lotic headwater habitats may make it vulnerable to deterioration of water quality, already reported in much of the French Broad drainage. How susceptible it may be to reduced water quality, however, remains to be determined by research.

References: Hobbs, H. H., Jr. 1972. Crayfishes (Astacidae) of North and Middle America. Biota of Freshwater Ecosystems, Ident. Man. No. 9. Environ. Protect. Agency, Washington, DC. 173 pages.
Hobbs, H. H., Jr. 1974. A checklist of the North and Middle American crayfishes (Decapoda: Astacidae and Cambaridae). Smithson. Contr. Zool. No. 166, Washington, DC. 161 pages.
Prins, R. 1968. A new crayfish of the genus *Cambarus* from North Carolina (Decapoda, Astacidae). J. Elisha Mitchell Sci. Soc. 84(4):458-461.
_____, and H. H. Hobbs, Jr. 1972. A new crayfish of the subgenus *Funcicambarus* from the Savannah River drainage with notes on *Cambarus* (P.) *reburus* Prins (Decapoda, Astacidae). Proc. Biol. Soc. Wash. 84: 411-420.

Authors: Martha R. Cooper and John E. Cooper.

Orconectes virginienensis Hobbs

CHOWAN RIVER CRAYFISH

Description: This is a strikingly patterned crayfish, with tan ground color marked with dark, bluish or blue black, saddles or near saddles. The tips of the chelae fingers are orange, banded with black, and there is a dark line on the outer edge of the stationary fingers. The chelae are strongly setiferous (with patches of "hairs"). Adults measure around 50 mm (2 in.) total length. The pattern may be lost in preserved specimens, which differ most obviously from other species described in North Carolina

in the presence of a rostrum with parallel sides and very strong spines, and in males having a first pleopod with two long terminal elements which continue in about the same direction as the main shaft. Diagnostic illustrations for the species are provided by Hobbs (1951, p. 126; 1974, p. 110) and keys for identification are in Fitzpatrick (1967) and in Hobbs (1972).

Distribution: Range -- Chowan River drainage in SE Virginia and extreme NE North Carolina, and one locality in lower Roanoke River drainage in Martin Co., North Carolina.

North Carolina -- Cutawhiskie Creek, trib. Potecasi Creek, Meherrin River (Chowan), Hertford Co.; Ready Branch, trib. Sweetwater Creek (Roanoke), Martin Co.

Habitat and Mode of Life: This species occurs in streams with slow to moderate current flowing through wooded areas. Substrates recorded are sandy or gravelly, and vegetation may be sparse. Nothing additional has been published on its natural history, which is virtually unknown in North Carolina.

Status: *Special Concern*. This is an apparently rare crayfish of limited distribution, whose occurrence in North Carolina has been verified in but two streams. It was the only member of its genus known to occur in North Carolina, and one of two in the United States east of the Appalachians, until the recent discovery by State Museum biologists of a new and as yet undescribed species in the Neuse River drainage. Further research may reveal that the species is *Endangered* or *Threatened* in the state.

- References: Fitzpatrick, J. F., Jr. 1967. The Propinquus Group of the crawfish genus *Orconectes* (Decapoda: Astacidae). *Ohio J. Sci.* 67(3):129-172.
- Hobbs, H. H., Jr. 1951. A new crayfish of the genus *Orconectes* from southeastern Virginia (Decapoda, Astacidae). *Va. J. Sci.* II (new series) (2):122-128.
- _____. 1972. Crayfishes (Astacidae) of North and Middle America. *Biota of Freshwater Ecosystems, Ident. Man. No. 9*. Environ. Protect. Agency, Washington, DC. 173 pages.
- _____. 1974. A checklist of the North and Middle American crayfishes (Decapoda: Astacidae and Cambaridae). *Smithson. Contr. Zool.* No. 166, Washington, DC. 161 pages.

Authors: Martha R. Cooper and John E. Cooper.

Freshwater and Terrestrial Arthropods -- Special Concern

DIPLOPODA; POLYDESMIDA; XYSTODESMIDAE
(Xystodesmid Millipeds)

Dixioria dactylifera Hoffman

Description: The dorsum of this species is black with yellow parana (margins), and has a yellow stripe along the anterior edge of the first segment. Ocelli (small eyes) are absent, and the body has twenty segments. It can be distinguished from all other diplopods, including other species of the genus, by the configuration of the male gonopods, which replace the anterior pair of legs on the 7th segment. Females have two pairs of normal legs on this segment, and are unidentifiable to species. Adults are usually about 33 mm (1 1/4 in.) long and 7.5 mm (5/16 in.) wide. See Hoffman (1956) for a gonopod illustration.

Distribution: Range -- North Carolina endemic; known definitely only from near Creston, vicinity Three Top Mountain, and Mt. Jefferson State Park, Ashe Co.

Habitat and Mode of Life: Xystodesmid millipeds typically occur in litter and under rocks and logs in predominantly hardwood localities. Nothing is known of the natural history of this species.

Status: *Special Concern*. This species is phylogenetically significant and should be maintained to observe future evolutionary trends in the genus. Since its total range is so restricted, it is deemed of particular concern to North Carolina. A higher category of concern is not justified at this time, as it is protected in the Park, and there is no known threat to the Three Top Mountain area where the species is relatively abundant. Clear cutting and resort development in this region, however, could be detrimental to the species. Further sampling in Ashe County is desirable to advance our knowledge of this species and other diplopods of the area.

Reference: Hoffman, R. L. 1956. Revision of the milliped genus *Dixioria* (Polydesmida: Xystodesmidae). Proc. U. S. Nat. Mus. 106:1-19.

Author: Rowland M. Shelley.

INSECTA; ODONATA; PETALURIDAE
(Petalurid Dragonflies or Graybacks)

Tachopteryx thoreyi (Hagen)

THOREY'S GRAYBACK

Description: The adult of this species is primarily characterized by certain head structures (an apically emarginate labium and an occiput which is swollen posteriorly), the clear wings, and the stigma in each wing being about nine times longer than wide. The body is about 7.6 cm (3 in.) long, and grayish brown or olivaceous in color. Dull orange markings are on some

segments of the abdomen. The nymph is characterized by the flat, quadrate, anteriorly cleft mentum of the labium, and by the stout, seven-segmented antennae which are shorter than the head. See Needham and Westfall (1955, pp. 67-75) for definitions of terms, keys, and illustrations.

Distribution: Range -- locally throughout much of eastern United States.

North Carolina -- reported from Wake and Wilkes cos.

Habitat and Mode of Life: According to Needham and Westfall (1955), the nymph lives "in bogs and other permanently wet spots buried in the mud of small pools that may contain very little water." They climb up on tree trunks to transform. The adults occur along small wooded streams, often resting on tree trunks. Eggs are often laid among the roots of grasses in wet areas, but not in water. The species apparently does not occur in coastal and lowland areas.

Status: *Special Concern*. The Petaluridae is a small, primitive family of wide but very disjunct distribution, containing only two North American genera. Thorey's Grayback is the only representative of this family in the eastern United States. Despite its wide distribution the species seems rare throughout its range. Its elimination from the North Carolina fauna would not only be a species deletion, but the loss of a family from the state.

Reference: Needham, J. G., and M. J. Westfall, Jr. 1955. A Manual of the Dragonflies of North America (Anisoptera). Univ. California Press, Berkeley and Los Angeles, CA. 615 pages.

Author: David L. Stephan.

INSECTA; MECOPTERA; MEROPEIDAE
(Earwigflies)

Merope tuber Newman

EARWIGFLY OR AMERICAN EARWIGFLY

Description: A scorpionfly 10 to 12 mm (3/8 to 1/2 in.) long, characterized by a short, slender rostrum, depressed body, relatively broad wings with numerous crossveins, and elongate, earwiglike genital claspers in the male. One of the most distinctive features of scorpionflies is their elongate chewing mouthparts, which are beaklike in appearance. Illustrations and descriptions are provided in Borror et al. (1976), Byers (1973), and Penny (1975).

Distribution: Range -- eastern and midwestern United States, south to N Georgia in the mountains.

North Carolina -- reported from Avery and Buncombe cos.

Habitat and Mode of Life: This scorpionfly is associated with woodlands, frequently near permanent streams. Adults have been found under logs and rocks. Recent collections have been made at portable lights and various kinds of traps, and often only a single specimen is taken at any locality. The larval and adult feeding habits are unknown.

Status: *Special Concern*. Recent records have extended the known range of this species into the Midwest, but it remains rare despite intensive collecting efforts. The immature stages and most of its life history are unknown. It is the only representative of its family in North America, one other occurring in Australia, and its extirpation would eliminate an entire family from the state.

References: Borror, D. J., D. M. DeLong, and C. A. Triplehorn. 1976. An Introduction to the Study of Insects. Fourth edition. Holt, Rinehart and Winston, NY. 852 pages.
Byers, G. W. 1973. Zoogeography of the Meropeidae (Mecoptera). J. Kansas Entomol. Soc. 46:511-516.
Penny, N. D. 1975. Evolution of the extant Mecoptera. J. Kansas Entomol. Soc. 48:331-350.

Author: David L. Stephan.

INSECTA; MECOPTERA; PANORPIDAE
(Common Scorpionflies)

Brachypanorpa carolinensis (Banks)

SHORTNOSED SCORPIONFLY

Description: The genitalia of males in this family are bulbous and recurved dorsally, resembling a scorpion's sting. This species is uniformly brownish with a reduced rostrum, and the female is moderately to strongly brachypterous (short-winged). Illustrations and descriptions are provided in Borror et al. (1976), Carpenter (1953), and Penny (1975).

Distribution: Range -- Virginia to Georgia in southern Appalachians. North Carolina -- known from Ashe, Buncombe, and Yancey cos., and Linville Falls (any of three cos.).

Habitat and Mode of Life: This species occurs in moist, shady woods from 900 to 2,000 m (3,000 to 6,700 ft.), and is not definitely associated with a particular plant community. H. H. Neunzig (pers. comm.) reported it from the grassy summit of Mt. Jefferson, Ashe County. Unlike other panorpidids, which are carnivorous, adults of *B. carolinensis* feed on soft leaf tissue. They appear for about three weeks at any locality, from May to July, the precise period depending on elevation. Immature stages are known, but apparently have not been described in the literature.

Status: *Special Concern*. The species is locally abundant at some

sites, but is generally rare throughout its restricted range. With specific collecting it may well prove to be more abundant and widespread.

- References: Borror, D. J., D. M. DeLong, and C. A. Triplehorn. 1976. An Introduction to the Study of Insects. Fourth edition. Holt, Rinehart and Winston, NY. 852 pages.
- Carpenter, F. M. 1953. The biology of *Brachypanorpa* (Mecoptera). Psyche 60:28-36.
- Penny, N. D. 1975. Evolution of the extant Mecoptera. J. Kansas Entomol. Soc. 48:331-350.

Author: David L. Stephan.

INSECTA; LEPIDOPTERA; LYCAENIDAE
(Lycaenid Butterflies; Hairstreaks, Coppers, and Blues)

Callophrys (=Mitoura) *hesseli* (Rawson and Ziegler) HESSEL'S HAIRSTREAK

Description: A small butterfly, with 21 to 24 mm (3/4 to 1 in.) wingspread. The imago or adult is characterized by the green underside of the wings with strong, dark-edged white markings. The caterpillar is probably 10 to 12 mm long, slug-shaped, and dark green with lighter, oblique lateral bars. Illustrations and descriptions are provided in Howe (1975) and in Klots (1951).

Distribution: Range -- New Hampshire to North Carolina.

North Carolina -- distribution not well known; presumably coincides with that of White cedar, which occurs in northeastern, southeastern, and southcentral parts of state (Radford et al. 1968, pp. 41-42). Records known from Fort Bragg, Cumberland Co.; Raeford, Hoke Co.; and Southern Pines, Moore Co. (P. A. Opler, pers. comm.).

Habitat and Mode of Life: Hessel's Hairstreak inhabits stands of White cedar, *Chamaecyparis thyoides*, on which the larva feeds. It produces two broods annually.

Status: *Special Concern*. This species lives in and is dependent on White cedar swamps, which are no longer abundant in the state (Wells 1967). Although this habitat occurs from Maine to Florida, *C. hesseli* is not known south of North Carolina. Very little is known of its life history. It was proposed for inclusion in the federal list of endangered and threatened species in March, 1975 (*Federal Register* 20/3/75), but apparently no further action has been taken. Until 1950 this species was confused with *C. (=M.) gryneus* (Hübner), to which it is very similar.

- References: Howe, W. H. (Ed.). 1975. The Butterflies of North America. Doubleday and Co., Inc., Garden City, NY. 631 pages.
- Klots, A. B. 1951. A Field Guide to the Butterflies. Houghton Mifflin Co., Boston, MA. 349 pages.

Freshwater and Terrestrial Arthropods -- Special Concern

Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. Manual of the Vascular Flora of the Carolinas. Univ. North Carolina Press, Chapel Hill, NC. 1,183 pages.

Wells, B. W. 1967. The Natural Gardens of North Carolina. Univ. North Carolina Press, Chapel Hill, NC. 458 pages.

Author: David L. Stephan.

INSECTA; LEPIDOPTERA; HESPERIIDAE
(Skippers)

Problema bulenta (Boisduval and LeConte)

RARE SKIPPER

Description: The Rare Skipper is quite similar to related species and genera. See Howe (1975) and Klots (1951) for illustrations and descriptions.

Distribution: Range -- Virginia to Georgia.
North Carolina -- known only from a few coastal localities, Brunswick and New Hanover cos.

Habitat and Mode of Life: Adults have been collected around freshwater marshes. The host or hosts are unknown, but it probably feeds on grasses, as do related species.

Status: *Special Concern.* Although this species was described in 1834, very few specimens have been collected anywhere. The species was proposed for inclusion in the federal list of endangered and threatened species in March, 1975 (*Federal Register* 20/3/75), but apparently no further action has been taken.

References: Howe, W. H. (Ed.). 1975. The Butterflies of North America. Doubleday and Co., Inc., Garden City, NY. 631 pages.
Klots, A. B. 1951. A Field Guide to the Butterflies. Houghton Mifflin Co., Boston, MA. 349 pages.

Author: David L. Stephan.

INSECTA; COLEOPTERA; CICINDELIDAE
(Tiger Beetles)

Cicindela ancocisconensis (Harr.)

Remarks: Cicindelids are highly active, often brightly colored, predatory beetles, usually around 10 to 12 mm (1/2 in.) long. This rare species is known only from Jackson-Haywood counties near Sunburst. It may be under some pressure from collectors.

Author: James F. Cornell, Jr.

INSECTA; COLEOPTERA; CARABIDAE
(Ground Beetles)

Anillinus n. sp. B

Anillinus n. sp. C

Remarks: These carabids are eyeless soil beetles, 2 mm long, found in moist soils and under stones. New species B is known from six specimens collected along the Uwharrie River near Ophir, Montgomery County. New species C is known from three specimens taken near Chapel Hill, Orange County.

Maronetus n. sp.

Maronetus tenuis Casey

Remarks: The members of this genus are small cychrine carabids which are found in forest litter in montane areas and feed on snails. T. C. Barr, Jr. (pers. comm.) reports the new species as a rare endemic from the Black Mountains near Asheville, Buncombe County. The locality of the rare *M. tenuis* is also in this area (T. C. Barr, Jr., pers. comm.). As snail eaters, these beetles will be affected by any pressures that might serve to eliminate their prey.

Pterostichus (*Cylindrocharis*) *hypogea* Barr

Remarks: This is a soil inhabiting beetle known from 20 specimens collected in Graham and Macon counties (Barr 1971).

Reference: Barr, T. C., Jr. 1971. The North American *Pterostichus* of the subgenus *Cylindrocharis* Casey (Coleoptera: Carabidae). Amer. Mus. Novitates 2445:1-14.

Stylulus (?) n. sp.

Remarks: Like *Anillinus*, these are small, eyeless beetles found in moist soils and under stones. This undescribed form, putatively assigned to the genus *Stylulus*, is known from two specimens collected in the South

Mountains near Morganton, Burke County (Cornell 1972).

Reference: Cornell, J. F., Jr. 1972. The eyeless beetles of North Carolina with notes on their ecology and evolution. J. Elisha Mitchell Sci. Soc. 88(4):260-264.

Trechus balsamensis Barr
Trechus carolinae Shaeffer
Trechus luculentus Barr
Trechus mitchellensis Barr

Trechus novaculosus Barr
Trechus rosenbergi Barr
Trechus satanicus Barr
Trechus subtilis Barr

Remarks: This genus is another group of small carabids, found associated with mosses and under stones in very moist situations in the high mountains of the southern Appalachians. Their known distributions and the number of known specimens (in parentheses), taken from Barr (1962), are: *T. balsamensis* (23), Haywood and Jackson cos., type locality Waterrock Knob; *T. carolinae* (10), peak of Mt. Mitchell, Yancey Co., type locality; *T. luculentus* (11), Haywood and Swain cos., type locality Clingmans Dome; *T. mitchellensis* ("numerous" at type locality, Celo Mountain), Yancey and McDowell cos.; *T. novaculosus* (12), Swain Co., type locality Clingmans Dome; *T. rosenbergi* (24), Haywood and Jackson cos., type locality Waterrock Knob; *T. satanicus* (11), Haywood Co., type locality Graveyard Fields near Devil's Courthouse; and *T. subtilis* (7), Haywood Co., type locality Mt. Sterling.

Reference: Barr, T. C., Jr. 1962. The genus *Trechus* (Coleoptera: Carabidae: Trechini) in the southern Appalachians. Coleopterist's Bull. 16(3):65-92.

Author: James F. Cornell, Jr.

INSECTA; COLEOPTERA; STAPHYLINIDAE
(Rove Beetles)

Lathrobium shermani Fall

Remarks: Rove beetles have short elytra (wing covers) and inhabit a variety of habitats. They are often attracted to carrion. This apparently rare, eyeless species is known only from the type specimen, collected in Yancey County (Brimley 1938).

Reference: Brimley, C. S. 1938. Insects of North Carolina. N. C. Dept. Agriculture, Raleigh, NC. 560 pages.

Author: James F. Cornell, Jr.

INSECTA; COLEOPTERA; PSELAPHIDAE
(Short-winged Mold Beetles)

<i>Arianops alticola</i> Barr	<i>Arianops nodosa</i> Barr
<i>Arianops barbata</i> Barr	<i>Arianops norithe</i> Barr
<i>Arianops coweeti</i> Barr	<i>Arianops parki</i> Barr
<i>Arianops fovealis</i> Barr	<i>Arianops plectrops</i> Casey
<i>Arianops gigantea</i> Barr	<i>Arianops spinicollis</i> Barr
<i>Arianops laminata</i> Barr	<i>Arianops teyahalee</i> Barr
<i>Arianops nantahalae nantahalae</i> Barr	<i>Arianops thornei</i> Barr
<i>Arianops nantahalae joanna</i> Barr	<i>Arianops unicoi</i> Barr

Remarks: This is a genus of small, eyeless pselaphids found under deeply embedded rocks and in deep, moist forest soil, in the southern Appalachians. They are difficult to collect. The majority of the described species have been collected from a relatively small number of localities, primarily in the region around the Coweeta Hydrologic Station. Some may be associated with subterranean driver ants of the genus *Amblyopone*. The known distributions and numbers are as follows (Barr 1974): *A. alticola* (52), Haywood and Macon cos.; *A. barbata* (6), Macon and Swain cos.; *A. coweeti* (34), Macon Co.; *A. fovealis* (2), Macon and Swain cos.; *A. gigantea* (4), Macon, Swain, and Transylvania cos.; *A. laminata* (7), Buncombe Co.; *A. n. nantahalae* (14), Clay and Macon cos.; *A. n. joanna* (4), Cherokee and Graham cos.; *A. nodosa* (5), McDowell and Yancey cos.; *A. norithe* (1), Graham Co.; *A. parki* (2), Macon and Swain cos.; *A. plectrops* (8), McDowell and Yancey cos.; *A. spinicollis* (17), Buncombe, Haywood, and Transylvania cos.; *A. teyahalee* (2), Cherokee and Graham cos.; *A. thornei* (5), Graham Co.; and *A. unicoi* (4), Graham Co. (also Monroe Co., Tennessee).

Mayetia spp. A, B, C

Mayetia bulla Shuster, Marsh and Park

Mayetia pearsei Shuster, Marsh and Park

Remarks: These are minute beetles, less than 1 mm long, found in soils. Some of the populations may be parthenogenetic (Shuster et al. 1959). The three undescribed species (A, B and C) were mentioned by Shuster et al. (1959) and were known only from females at that time. *Mayetia bulla* occurs in Orange County, and *M. pearsei* is known from Duke Forest, Orange County.

References: Barr, T. C., Jr. 1974. The eyeless beetles of the genus *Arianops* Brendel (Coleoptera: Pselaphidae). Bull. Amer. Mus. Nat. Hist. 154(1):1-51.
Shuster, R. O., G. A. Marsh, and O. Park. 1959. A revision of the Mayetini. Pan Pacific Entomol. 35:117-127.

Author: James F. Cornell, Jr.

INSECTA; COLEOPTERA; LEPTODIRIDAE
(Small Carrion Beetles)

Adelopsis mitchellensis (Hatch)

Remarks: Leptodirids are small, ovate beetles, 2 to 5 mm long, which inhabit moist forest litter or soil. The length of *A. mitchellensis* is 2.3 to 2.6 mm. This is the only currently described species of the genus in the United States, and it is known only from the Black Mountains of Yancey County, including Mt. Mitchell. Peck (1973) collected specimens in the balsam forest atop Mt. Mitchell with a carrion-baited pitfall trap, and surmised that other specimens "were probably taken by sifting litter and moss." He also reported that a second, undescribed species occurs on Mt. Mitchell, whose range extends "through the Smoky Mountains to north-eastern Alabama."

Reference: Peck, S. B. 1973. A systematic revision and the evolutionary biology of the *Ptomaphagus* (*Adelops*) beetles of North America (Coleoptera; Leiodidae; Catopinae), with emphasis on cave-inhabiting species. Bull. Mus. Comp. Zool. Harvard Univ. 145(2):29-162.

Author: James F. Cornell, Jr.

INSECTA; COLEOPTERA; LEIODIDAE
(Round Fungus Beetles)

Agathidium n. sp.

Remarks: The Leiodidae are shiny, oval beetles, 1.5 to 6.5 mm long, generally found in fungi and molds. Some subcortical species feed on the sporangia of myxomycetes such as *Trichia* and *Stemonitis*. This undescribed species of *Agathidium*, which has reduced eyes, is known from a few specimens collected on Mt. Pisgah, Buncombe-Haywood County (J. Wheeler, pers. comm.).

Author: James F. Cornell, Jr.

INSECTA; HYMENOPTERA; FORMICIDAE
(Ants)

Formica exsectoides Forel

ALLEGHANY MOUND ANT

Description: The workers of this species vary in size, with some of the larger attaining a length of 10 mm (3/8 in.). The head, thorax, and petiole are light red to chestnut in color and the gaster dark brown to

black. Some other species of *Formica* are of the same general size and coloration. The workers can be distinguished from other species in the same group by the presence of numerous erect hairs on the promesonotum, lower edge of pronotum, fore coxae, and on all segments of the gaster. These are absent or sparse on corresponding parts of the other species. Identification keys are provided in Creighton (1950).

Distribution: Range -- Nova Scotia to Georgia, west to Ontario and Wisconsin.

North Carolina -- about 50 acres in Alleghany Co., ca. 3 km (2 mi.) NW of Glade Valley, E of county road 1444.

Habitat and Mode of Life: The Alleghany Mound Ant occurs in wooded clearings, along woods roads, and in an open field now growing in young pine. There are numerous small mounds present, less than a dozen large mounds nearly a meter (3.2 ft.) high and 5 m in diameter, and some mounds that appear to have been deserted due to excessive shading. It is the dominant ant in the area and the population appears to have thrived for over 25 years. The females establish their colonies by temporarily parasitizing small colonies of *Formica fusca* var. *subsericea*. The workers are very aggressive. Their food is small arthropods, honeydew, and the sap of plants. The species has been considered a pest in some tree nurseries.

Status: *Special Concern*. Only one population of this ant is known in North Carolina. Perhaps the greatest threat to its survival is the continued growth of small trees in the area shading it out. There have been some complaints by local citizens about its being a pest, thus the colony appears to be thriving at present.

Remarks: Three species of myrmecophilous beetles of the family Pselaphidae are dependent on this ant for survival (see accounts by J. F. Cornell, Jr., in this chapter).

References: Creighton, W. S. 1950. The Ants of North America. Bull. Mus. Comp. Zool. Harvard Coll. 104:1-585.
Smith, M. R. 1950. Synopsis of United States ants. Amer. Midl. Natur. 37:521-647.

Author: James F. Greene.

Freshwater and Terrestrial Arthropods -- Undetermined

The following rare species are of *Undetermined* status. All beetle accounts were prepared by James F. Cornell, Jr.

INSECTA; COLEOPTERA; CARABIDAE
(Ground Beetles)

Agonum (Platynidus) gracilentum Beut.

Remarks: Occurs in the Black and Great Smoky mountains.

Maronetus unistriatus Darlington

Remarks: Occurs in the Nantahala Mountains and Highlands Plateau.

Nebria appalachia Darlington

Remarks: Occurs in the Great Smoky and Great Balsam mountains.

Pterostichus blanchardi Horn

Remarks: Occurs in southwestern Virginia, northern Tennessee, and North Carolina.

Pterostichus carolinus carolinus Darlington

Remarks: Occurs in the Black Mountains.

Pterostichus carolinus fumorum Darlington

Pterostichus (Gastrellarius) unicarum Darlington

Pterostichus (Haplocoelus) primus Darlington

Remarks: Occur in the Great Smoky Mountains.

Pterostichus lubricus LeConte

Remarks: Occurs in the Great Balsam Mountains, to Georgia.

Pterostichus manicus plethorus Darlington

Remarks: Occurs in the Black Mountains, and on Roan and Grandfather mountains.

Pterostichus palmi Schaeffer

Remarks: Occurs in the Bald, Balsam, Black, and Great Smoky mountains.

Scaphinotus guyoti LeConte

Scaphinotus violacea LeConte

Remarks: Occur in the Great Balsam Mountains. Barr (1969) considers these species, and all of those mentioned above, to be rarer endemics of the southern Appalachians. Consult this reference for details.

Reference: Barr, T. C., Jr. 1969. Evolution of the (Coleoptera) Carabidae in the southern Appalachians. In: P. C. Holt (Ed.). The Distributional History of the Biota of the Southern Appalachians. Part I: Invertebrates. Res. Div. Monogr. No. 1, Va. Polytech. Inst. State Univ., Blacksburg, VA:67-92.

Author: James F. Cornell, Jr.

The four species which follow are myrmecophiles (ant associates). They are probably not in danger unless the host ants are destroyed, which could result from non-specific applications of insecticides. Those associated with the Alleghany Mound Ant, *Formica exsectoides*, are living with an ant that is near the southern limit of its distribution in northwestern North Carolina (Alleghany County). This ant would probably be most susceptible to any pressures placed on it.

INSECTA; COLEOPTERA; PSELAPHIDAE
(Short-winged Mold Beetles)

Ctenisius sp.

Pilopius sp.

Remarks: Specimens representing species of these two genera were collected from nests of the Alleghany Mound Ant in Alleghany County.

INSECTA; COLEOPTERA; LIMULODIDAE
(Horse-shoe Crab Beetles)

Limulodes paradoxus Math.

Remarks: This species is nowhere common, and has been collected only once in North Carolina, with *Lasius* ants in Wake County (Cornell 1967, 1973).

References: Cornell, J. F., Jr. 1967. New Coleoptera records from North Carolina. Proc. Entomol. Soc. Wash. 69(1):81.
Cornell, J. F., Jr. 1973. The endangered beetle species list: progress and problems. J. Elisha Mitchell Sci. Soc. 89(4):250.

INSECTA; COLEOPTERA; HISTERIDAE
(Hister Beetles)

Hetaerius sp.

Remarks: Specimens of an undetermined member of this genus have been collected from mounds of the Alleghany Mound Ant.

Freshwater and Terrestrial Arthropods -- Undetermined

INSECTA; COLEOPTERA; SCARABAEIDAE
(Scarab Beetles)

Lichnanthe (=Amphicoma) vulpina Hentz

Remarks: This rare scarab is found in cranberry bogs, supposedly from the mountains of the Carolinas to Pennsylvania. The author has seen no specimens collected in either of the Carolinas since 1940. It is reported from Spruce, Round Knob, Retreat, and Swannanoa, in Buncombe, McDowell, and Yancey counties (Brimley 1938), but may be *Extirpated*.

Reference: Brimley, C. S. 1938. Insects of North Carolina. N. C. Dept. Agriculture, Raleigh, NC. 560 pages.

Psilocnemis leucosticta Burmeister

Remarks: This extremely rare scarab, a commensal of ants, occurs from Maryland to North Carolina, but has been collected fewer than a dozen times since it was described in 1842. More than half the known specimens are from a small area near Balsam, Haywood County, North Carolina. This area is under considerable pressure from development and increasing population.

INSECTA; COLEOPTERA; COLYDIIDAE
(Cylindrical Bark Beetles)

Aglenus brunneus (Gyll.)

Remarks: This is a rare beetle of Swain and Haywood counties, found in the nests of small mammals. It has been collected from lodges of the Wood Rat, *Neotoma floridana*, in the Great Smokies, and from mammal runs under logs in both counties (Cornell 1971, 1972).

References: Cornell, J. F., Jr. 1971. An open letter to coleopterists concerning extinction of beetles. *Coleopterist's Newsletter* 2(1): 2-3.

Cornell, J. F., Jr. 1972. The eyeless beetles of North Carolina with notes on their ecology and evolution. *J. Elisha Mitchell Sci. Soc.* 88(4):260-264.

Author: James F. Cornell, Jr.

INSECTA; HYMENOPTERA; FORMICIDAE
(Ants)

Amblyopone (=Stigmatomma) *trigonignatha* Brown

Remarks: This species is similar to *A. (=S.) pallipes* (Haldeman), differing primarily in the dentition of the mandible and the anterior margin of the clypeus. Brown (1949) and Creighton (1950) provide diagnostic illustrations and descriptions. It is a North Carolina endemic, known only from the type locality at Concord, Cabarrus County. Its primary habitat is unknown, but it may be strongly hypogean. The type and only known specimen was taken in a leaf mold sample collected from the banks of Buffalo Creek at its intersection with highway 49 by D. L. Wray, along with a specimen of *A. (=S.) pallipes*. According to W. L. Brown, Jr. (pers. comm.), no additional specimens have been found in museums and no others have ever been collected. This is the species referred to as *Stigmatomma* sp. in the tentative list issued following the 1975 Symposium.

References: Brown, W. L., Jr. 1949. A new American *Amblyopone* with notes on the genus (Hymenoptera: Formicidae). *Psyche* 56:81-88.
Creighton, W. S. 1950. The Ants of North America. *Bull. Mus. Comp. Zool. Harvard Coll.* 104:1-585.

Author: David L. Stephan.

Discussion

Ed Menhinick: Would you comment on the spider that was shown on the screen?

Tom Daggy: No. I can comment on the spiders that are on our list.

Menhinick: That looked very similar to a spider which was recently described from caves in Tennessee, and I was wondering if that wasn't the same thing.

Martha Cooper: That one was from a cave in Tennessee. There is also one from a cave in North Carolina.

Daggy: The one on our list was, of course, from a cave in North Carolina, and it was similar to that, but we didn't have a picture of the one from North Carolina.

Rowland Shelley: What was the terrestrial isopod? You said there was one terrestrial isopod of Special Concern, what was that? Was it *Oniscus asellus*?

Cooper: It was *Miktoniscus alabamensis*, also a frequent cave species, which is known in North Carolina only from Linville Caverns.

Shelley: The southernmost record of *Oniscus asellus* is from Haywood County, and to my knowledge it hadn't been reported south of the West Virginia area with the exception of that particular record.

Cooper: Perhaps we can add that to the publication.

Other Invertebrates

by

John E. Cooper and Rowland M. Shelley

Although the three major groups of invertebrates considered at the 1975 Symposium were Freshwater and Terrestrial Mollusks (pages 143-194), Freshwater and Terrestrial Arthropods (pages 195-230), and Marine Invertebrates (pages 233-249), there are other non-marine invertebrates which deserve some mention. Little is known about these invertebrates in North Carolina. Most groups have received scant attention from professional zoologists, and our knowledge at this stage is extremely limited. A few species should be mentioned briefly, however, to underscore their occurrence and apparent rarity in the state. All are currently considered to be of *Undetermined* status.

Two indigenous terrestrial flatworms or planarians (Turbellaria; Tricladida; Terricola; Rhynchodemidae) occur uncommonly in North Carolina. *Microplana atrocyaneus* (Walton), a cylindrical, uniformly black triclad with a lighter creeping sole, is recorded from under leaves in the Black Mountains of Yancey County; Bat Cave, Henderson County; and at Roaring Gap, Alleghany County. The total length of adults when fully extended is about 25 mm, and there are two small eyes near the anterior tip of the body. The species is also known from Arkansas, Illinois, Kentucky, Missouri, Ohio, Tennessee, and Virginia. *Diporodermus indigenus* Hyman is a longer (60-70 mm extended), more slender, and dark, slaty gray species. Known North Carolina localities include Newfound Gap, Clingman's Dome, and near Bryson City, Swain County; near Glen Ayre, Mitchell County; and Wallace Gap in the Nantahala Mountains near Slagle, Macon County. It has also been reported from Michigan and New York. See Hyman (1954) for additional information on these flatworms.

An unidentified rhynchodemid was collected by John C. Clamp in the summer of 1975 from the disjunct White Pine community on the Rocky River, approximately 11.3 km (7 mi.) south of Pittsboro, Chatham County. The specimen was immature and may be distinct from the preceding species. This is the first collection of a land planarian in the Piedmont Plateau region of the state.

Dr. John W. Reynolds of the Department of Forest Resources, University of New Brunswick, Fredericton, New Brunswick, Canada, supplied some information on the following earthworms.

Komarekiona eatoni Gates is a poorly known earthworm described in 1974 from near the border between Durham and Orange counties, North Carolina. Parthenogenetic (reproducing by the development of unfertilized ova) populations are known from four other states, but the North Carolina population is biologically significant in apparently being amphimictic (reproducing by male-female sexual union). Several unique anatomical features led Gates (1974) to erect a monotypic family, Komarekionidae, and genus to accomodate this form. The type locality has largely been destroyed by construction, and this worm was considered *Endangered* in the preliminary list of endangered species issued by the North Carolina Department of Natural and Economic Resources (DNER 1973).

Sparganophilus pearsei Reynolds was described in 1975 from a site in Buncombe County, North Carolina. It was originally taken by A. S. Pearse

in the 1930's, and may no longer occur at that locality. A few specimens have been collected from one county in Georgia and one in central Florida. Dr. Reynolds points out (pers. comm.) that it is difficult to discuss earthworm biogeography since so few studies have been conducted on these organisms. Vigility is limited and, if a small population's habitat is destroyed, in all likelihood the population will be extirpated.

A polychaete annelid worm, *Manayunkia speciosa* Leidy (family Sabellidae), is one of the few polychaetes to inhabit freshwater. It appears to be common in the northern United States and occurs as far south as the Savannah River, South Carolina. The only known North Carolina locality is Lake Waccamaw, Columbus County (Mackie and Qadrie 1971, Spencer 1976). This worm is probably more widespread in the state, but escapes notice due to its small size (3-5 mm). It is figured in Pennak (1953:301). The species was listed as status *Undetermined* in the 1973 DNER report.

Two freshwater sponges, *Corvomeyenia carolinensis* and *Spongilla spongiosa*, known only from their respective type localities in South Carolina, were included in a 1975 U. S. Fish and Wildlife Service notice of review to determine their status for possible listing as *Endangered* or *Threatened*. These, or other species potentially in jeopardy, may occur in North Carolina, but no freshwater sponges in this state are currently under investigation. Dr. Frederick W. Harrison of the Albany Medical College of Union University, Albany, New York, says (pers. comm.), "This may, unfortunately, reflect the general lack of collecting, not only in North Carolina, but throughout the U. S. A.".

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Marine Invertebrates

Introduction

by

Hugh J. Porter, Charles Johnson, and Anne B. McCrary

Probably no free-living marine invertebrates on the east or west coasts of the United States are threatened with extinction. Abbott (1970), Keen (1970), and Morrison (1970) also support this view. There are, however, a number of species whose existence in North Carolina waters may be threatened by destruction of their habitat or by over-utilization. Such species are of *Special Concern*. Their listing is not definitive, but a beginning, and the number may change as understanding of North Carolina's marine and estuarine waters and their fauna increases.

The North Carolina marine invertebrate fauna is extensive but imperfectly known. That of the Beaufort area is best documented (note Kirby-Smith and Gray, 1971, and the number of references they list); elsewhere relatively few taxonomic or ecological studies have been made or are in progress. Williams (1965) lists 220 decapod crustaceans from North Carolina marine waters. Fox and Bynum (1975) list 74 species of amphipods, 16% known from only one or two collected specimens. Porter (1974) lists 1,200 to 1,300 kinds of marine and estuarine mollusks. Day (1973) lists 323 species of polychaete worms, 16 of which are new to U. S. waters and about 13% of which are known from only one or two specimens. Gardiner (unpublished manuscript) reduced Day's polychaete number to about 270 forms. Other invertebrate groups are not nearly as well known; thus, it is difficult to even list let alone determine those species of concern. It cannot be denied that ecologically unsound engineering practices, waste disposal, deforestation, fishing, urban development, biological collecting, agricultural practices, and other activities of man have seriously changed environments, and with them the biotic composition of affected areas.

Our initial statement that there are probably no free-living marine invertebrates threatened with extinction does not apply to symbiont invertebrates which are not free-living. In a recently completed manuscript Johnson discusses the number of symbionts, species living in a commensal or parasitic relationship to their hosts and dependent upon the latter for survival, from 16 such North Carolina vertebrates. For example: Humpback Whale, *Megaptera novaeangliae*, at least 10 symbionts; American Alligator, *Alligator mississippiensis*, over 10; and Loggerhead Turtle, *Caretta caretta*, over 40. Because these vertebrates are considered to be in jeopardy, their symbionts must also be considered endangered.

Marine and estuarine invertebrates of *Special Concern* having symbiotic communities are the Parchment Tube Worm, *Chaetopterus variopedatus*; the polychaete worm, *Notomastus lobatus* (believed to have about six symbionts in its community); and an echiurid worm, *Thalassema hartmani*. The bivalve, *Paramya subovata*, a symbiont of the latter, is included with its listing. Other symbionts of the above-listed vertebrates and invertebrates cannot be discussed individually because of the incomplete state of our knowledge.

The estuarine or brackish-water community in North Carolina is in greatest danger of being adversely affected by man. In a 1968 symposium on rare and endangered mollusks Morrison (1970) stated, "In North America man continues to unconsciously endanger and to ignorantly exterminate

brackish water species every time a marina is built, dug, dredged In the same way today's real-estate developments with land fills, and dredged or blasted canals, designed to increase the number of water-front lots for sale, are deadly to estuarine species. Another modern water 'conservation' plan to impound fresh waters in lowland reservoirs by damming estuaries, prevents effective mingling with saline waters, and so narrows or destroys the brackish water habitat." Most species included in the accompanying accounts occur within North Carolina's estuaries at least during part of their lives.

To understand why marine and estuarine invertebrates may become endangered it is helpful to separate them into three categories: (1) species repopulated by non-pelagic dispersal; (2) species imported by pelagic larval drift; and (3) species repopulated by native pelagic larvae.

(1) Species repopulated by non-pelagic dispersal do not have a free-swimming stage and are not dependent on currents for movement. Young are released from eggs as crawling juveniles, or, in certain primitive invertebrates, reproduced asexually by budding. Because their spread is restricted only to neighboring habitats, adverse localized environmental changes could have a severe impact upon them. Best known among this group are certain large mollusks which are easily collected, like the Channeled Whelk, *Busycon canaliculatum*; Knobbed Whelk, *Busycon carica*; and Lightning Whelk, *Busycon contrarium*. These are considered of *Special Concern* because major populations occurring in the Cape Lookout region have at times been severely exploited by commercial interests (for making conch chowder) and shell collectors. Examples from other invertebrate groups which may be endangered or threatened were not known to us or the Marine Invertebrate Committee.

(2) Species imported into North Carolina waters by pelagic larval drift may be present as the result of propitious environmental conditions coupled with favorable ocean currents at or just following spawning by adults. Scheltema (1970) documented a number of mollusks that are transported long distances along our east coast by larval drift from more southern areas. Examples were the Florida Rock Shell, *Thais haemastoma floridana*; Giant Tun, *Tonna galea*; Scotch Bonnet, *Phalium granulatum*; and von Salis' Triton, *Cymatium parthenopeum*. When these species are at their northern and southern range limit, adults may not be capable of spawning. Numbers of living examples of the latter two species have not been observed since 1972 and 1973. Porter (unpublished data) has evidence that a population of the Southern Quahog, *Merccenaria campechiensis*, living in North Carolina's offshore waters near the northern limit of its range, did not spawn for at least two or perhaps three consecutive years. Commercial quantities of the Calico Scallop, *Argopecten gibbus*, have not occurred since 1973.

Many, if not most, rare marine and estuarine invertebrates in North Carolina are present because of occasional larval drift from more populous northern or southern sites. Lack of knowledge prevents their being listed. If breeding populations in areas which furnish larvae for these species were reduced to critically low numbers, their continued existence in North Carolina waters would be in jeopardy and thus cause for concern. Adverse environmental changes beyond our boundaries could well have an impact upon species now found here, and in these cases we have no real control. Such alterations could conceivably affect the future of the Calico Scallop fishery, if our population is eventually found to be dependent

upon breeding populations farther south for replenishment.

(3) The capacity of native marine invertebrates to repopulate themselves through larval drift patterns in North Carolina is an unknown factor, though work by Sandifer (1975) in Virginia, and Costlow and Bookhout (1964), gives a number of indications. It is doubtful that endemic marine members of this group are presently in any danger from man-caused disturbances. While some scientists believe that most eggs and/or larvae produced by invertebrates off our coast are carried out of these waters by prevailing offshore currents before they can metamorphose into juveniles or adults, members of this Committee believe otherwise. Among decapod crustaceans in the Carolinian Province, 29% of the penaeids, 31% of the carideans, 50% of the lobsters, 36% of the anomurans, and 28% of the crabs have life histories known sufficiently to leave little doubt that they are native. Fragmentary knowledge of the rest is not contradictory. This is suggestive that the majority of our invertebrate species fall in this category.

If the Calico Scallop belongs to this group and not to group 2, over-harvesting of it in previous years probably had a serious effect on its later populations, thus the status of *Special Concern*. Other invertebrates believed to be in this group and given the same status are *Chaetopterus variopedatus*, *Notomastus lobatus*, *Thalassema hartmani*, *Detracia clarki*, *Neritina usnea*, *Panopea bitruncata*, and *Paramya subovata*.

Most *Special Concern* invertebrates are in this group and spend part of their lives in North Carolina's estuaries. The same is true of most invertebrates commercially important to North Carolina fisheries, like the Blue Crab, *Callinectes sapidus*; Brown, Spotted, and White Shrimp, *Penaeus aztecus*, *P. duorarum* and *P. setiferus*; Bay Scallop, *Argopecten irradians concentricus*; Eastern Oyster, *Crassostrea virginica*; Northern Quahog, *Mercenaria mercenaria*; Common Rangia Clam, *Rangia cuneata* (occurring in great numbers in low salinity waters, it may be an important secondary food source for man); and the Balthica Macoma, *Macoma balthica* (also living in low salinities and a probable important food source for fish or waterfowl). Not included are the many other invertebrate species fed upon by commercially important fish or invertebrates. The abundance or existence of all of these will be drastically affected by perturbations or destruction in our estuaries.

Based on our deliberations, the Marine Invertebrate Committee believes that the whole estuarine region could be damaged by man-caused environmental changes. Over-collecting by educators, scientists, and other collectors in the Cape Lookout, Bird Shoal, and Wrightsville Beach areas may be cause for additional concern.

Members of the Committee besides the authors of this report were Charles E. Jenner and Austin B. Williams. Special appreciation is accorded the latter for his detailed review and editing of this report. Serving also on the Committee was Edward P. Ryan.

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Marine Invertebrates -- Species List and Accounts

Species List

Species	Status
Annelida	
Polychaeta	
<i>Chaetopterus variopedatus</i> , Parchment Tube Worm 237	Special Concern
<i>Notomastus lobatus</i> , Polychaete Worm 238	Special Concern
Echiurida	
<i>Thalassema hartmani</i> , Hartman's Echiurid Worm 239	Special Concern
Mollusca	
Gastropoda	
<i>Busycon canaliculatum</i> , Channeled Whelk 246	Special Concern
<i>Busycon carica</i> , Knobbed Whelk 246	Special Concern
<i>Busycon contrarium</i> , Lightning Whelk 246	Special Concern
<i>Detracia clarki</i> , Clark's Melampus 248	Special Concern
<i>Neritina usnea</i> (= <i>Neritina reclivata</i>), Olive Nerite 245	Special Concern
Bivalvia	
<i>Argopecten gibbus</i> , Calico Scallop 240	Special Concern
<i>Panopea bitruncata</i> , Atlantic Geoduck 242	Special Concern
<i>Paramya subovata</i> , Subovate Soft Clam 239	Special Concern

SPECIES ACCOUNTS

ANNELIDA; POLYCHAETA; CHAETOPTERIDAE (Tube-dwelling Polychaetes)

Chaetopterus variopedatus (Renier) PARCHMENT TUBE WORM

Description: A tube-dwelling worm with three quite different body regions, the middle of which has a trio of circular, fan-like appendages. The tube is brown, opaque, and parchmentlike or leathery. See Barnes (1964, pp. 187-188) and Hickman (1967, p. 296).

Distribution: Range -- cosmopolitan in temperate and tropical seas, from intertidal to 100 m (328 ft.).

North Carolina -- marine flats from intertidal zone to 30 m (100 ft.), between Cape Hatteras and Beaufort.

Habitat and Mode of Life: This polychaete lives on mud flats in a U-shaped tube buried in the sand, with only the small ends of the tube projecting above the surface. Food consists of organic debris and plankton, brought into the tube by water currents produced by the beating of the fans.

Status: *Special Concern.* This species is considered to be of this status because of its interest to biologists. It is one of the classic organisms studied in biology courses, and populations of *Chaetopterus* have a tendency to decrease rapidly in areas adjacent to marine laboratories. In view of the increasing scientific usage of the marine environments in North Carolina, it seems wise to give this polychaete particular consideration.

References: Barnes (1964), Gosner (1971), Hickman (1967), see list following introduction.

Author: Anne B. McCrary.

ANNELIDA; POLYCHAETA; CAPITELLIDAE
(Capitellid Polychaetes)

Notomastus lobatus Hartman

POLYCHAETE WORM

Description: This is a reddish polychaete worm with a conical head and an eversible proboscis. It has no distinct eyes or tentacles, and grows to a length of about 76 cm (29 in.).

Distribution: Range -- Atlantic Coast, and Gulf of California to Mexico.

North Carolina -- near Beaufort and Wrightsville.

Habitat and Mode of Life: The animal lives in coiled, mucus-lined burrows in soft mud of the intertidal and subtidal zones. It is a deposit feeder.

Status: *Special Concern.* This polychaete is of particular interest because of the assemblage of organisms which are found associated with it. These include an undescribed species of highly modified commensal clam of the genus *Entovalva* which attaches to its body, and a scale worm, *Lepidasthenia varia*, which shares its burrow. The scale worm is known from the Galapagos, Dry Tortugas, Costa Rica, and North Carolina. It also has a commensal clam associated with it, and an entoproct is frequently found attached to its scales.

There are no data on the size of the *N. lobatus* population or the distribution of suitable habitat in North Carolina waters. Our concern, then, is the same concern we have for all marine invertebrates: the maintenance of adequate habitat and suitable environmental conditions to insure their survival.

References: Day (1973); see list following introduction.
Hartman, O. 1947. Polychaetous Annelids. Part 7. Capitellidae.

Allan Hancock Pacific Expeditions 10:391-481.

Jenner, C. E., and A. McCrary. Commensal Bivalves from North Carolina Coast (unpublished manuscript).

Author: Anne B. McCrary.

ECHIURIDA; THALASSEMATIDAE
(Echiurid Worms)

MOLLUSCA; BIVALVIA; MYIDAE
(Soft-shell Clams)

Thalassema hartmani Fisher

HARTMAN'S ECHIURID

Description: An unsegmented, sausage-shaped and reddish worm with a proboscis and trunk. Length about 40 mm (1 1/2 in.). See Fisher (1947) for a more detailed description, and Gosner (1971) for a line drawing.

Distribution: Range -- essentially Carolinian, but also reported from Chesapeake Bay.

North Carolina -- intertidal zone of Wrightsville Beach and Beaufort.

Habitat and Mode of Life: This echiurid lives in burrows in sandy mud on intertidal flats. It feeds on microorganisms by ciliary action, moving them to the mouth along a trough in the proboscis.

Paramya subovata (Conrad)

SUBOVATE SOFT CLAM

Description: A small, subquadrate, gray clam with concentric growth lines. The hinge has a large triangular and vertically-directed pit. See Abbott (1974) for an illustration.

Distribution: Range -- Delaware to Florida and Texas waters.

North Carolina -- Beaufort and Wrightsville Beach areas.

Habitat and Mode of Life: Jenner and McCrary (1970) described the commensal relationship which exists between *T. hartmani* and *P. subovata*. Evidence seems to indicate that the clam may be host-specific to the echiurid, and that it is present in the sediments adjacent to worm burrows, with its exhalent and inhalent siphons opening into the burrow cavity. They found as many as five of the bivalves with a single worm.

Status: *Special Concern*. *Thalassema hartmani* is rarely found by sediment biologists in its type locality at Beaufort. Several populations were known to occur in the Wrightsville Beach area, and one has since been destroyed by beach development. Because of the commensal relationship between the two species, there is a possibility that they may be over-collected for scientific and educational purposes.

References: Abbott (1974), Gosner (1971); see list following introduction.

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Authors: Hugh J. Porter and Anne B. McCrary.

MOLLUSCA; BIVALVIA; PECTINIDAE
(Scallops)

Argopecten gibbus (Linne)

CALICO SCALLOP

Description: A bivalve having an upper valve (shell) with red or maroon calico markings over a white or yellow base, and a whitish bottom valve with some color. The valves are quite fat. Old bleached shells are frequently confused with the Bay Scallop, *Argopecten irradians*. Generally the red or maroon calico markings on the dorsal valve of the Calico Scallop distinguish it from the solid gray or brown dorsal valve of the Bay Scallop. Height (straight line measurement between umbo and ventral margin) averages about 50 mm (2 in.), with occasional valves up to almost 75 mm (3 in.). The shell has 17 to 23 ribs. See Figure 1 and also see Abbott (1974, pp. 447-448) and Waller (1969).

Distribution: Range -- Western North Atlantic from N side Greater Antilles, throughout Gulf of Mexico to Bermuda, to slightly N Cape Hatteras, in depths from 2 to 370 m (6.5 to 1,200 ft.) (Waller 1969; Allen and Costello 1972).

North Carolina -- variably distributed between Cape Hatteras and Cape Fear. Cummins et al. (1962) characterized grounds as an elliptical-shaped bed 16 km (10 mi.) long near Cape Lookout with several beds NE and SW of the Cape. In 1966-67 bed was SW of Cape Lookout, with a small bed occurring SE of New River Inlet in 1967 (Porter and Wolfe 1972). In 1970-71 major bed was NE to E of Cape Lookout with small beds from Drum Inlet to Cape Lookout and SW of Cape Lookout at 18 to 30 m (60 to 100 ft.) (Porter 1972; Porter and Wolfe 1972). In 1972 bed was 19 to 24 km (12 to 15 mi.) S of Beaufort Inlet at 27.5 m (90 ft.) (Porter and Schwartz 1973) and in 1973 was NE of Cape Lookout (Porter and Schwartz, unpublished data).

Habitat and Mode of Life: Critical North Carolina habitat is not known. In a 1972 survey of the bed occurring S of Beaufort Inlet, no measured difference could be detected between areas containing scallops and those without. The 1972 bed occurred on hard sand bottom, whereas the 1973 bed was on shelly bottom. Substrate preference may vary with the size of scallops. Young up to 25 mm (1 in.) in length are found attached to whole or broken mollusk shells (Commercial Fisheries Review 1962) or live scallops (Wells et al. 1964). Thus, shell beds may be preferred for settlement by this size group (Kirby-Smith 1970). Larger unattached scallops have been reported from bottoms composed of a wide variety of sediments (Cummins et al. 1962; Drummond 1969; Grassle 1967; Rivers 1962; and others).

Reproduction: Calico Scallops are hermaphroditic, with fertilization occurring in open water. Male gonad tissue is cream colored and gonad tissue of ripe females is orange red. Roe et al. (1971) state that minimum age for sexual ripeness can be quite young, but in Florida waters is generally seven to nine months, with a life span of 18 to 24 months. They further suggest that spawning is initiated by rising temperatures. Time of spawning in North Carolina is variable in May and June (Kirby-Smith 1970; Porter 1972; Porter and Schwartz, unpublished). The latter authors suggest that a September spawning is possible.

Status: *Special Concern.* Severe damage to Calico Scallop beds caused by the commercial fishery may have contributed to the significant declines which occurred in 1962-64, 1968-69, and 1974-75 (Chestnut and Davis, 1975, provide data for 1959-74). Since fishery exploitation began in 1959 the offshore beds have yielded between 6,000 and 1,857,000 pounds of meats, with values up to \$498,000 annually. Harvesting frequently takes place before and during spawning, as the fishermen maintain that scallop condition deteriorates following reproduction. Once scallops reach economically valuable size and quantity, they are fished until returns are unprofitable. If the beds are dependent upon larvae from native adults for repopulation, harvest before or during spawning may reduce the possibility of a good population the following year.

Research is needed to determine whether the beds are capable of repopulating themselves. Death of the beds occurred in 1972, and we need data to determine whether this was caused by fishing destruction or other causes. If the beds are dependent upon themselves for repopulation, then regulation of commercial harvest may be needed in order to maintain this species in North Carolina.

Remarks: The seastars, *Luidia clathrata* and *Astropecten articulatus* were active, abundant predators on the 1972 bed (Porter and Schwartz 1973). These authors list 21 less abundant macroinvertebrates associated with the scallop which are suspected predators. Six fishes commonly frequenting the bed fed readily on the Calico Scallop.

References: Abbott (1974); see list following introduction.

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Author: Hugh J. Porter.

MOLLUSCA; BIVALVIA; HIATELLIDAE
(Saxicaves, Propeller Clams, Rough Myas, and Geoducks)

Panopea bitruncata (Conrad)

ATLANTIC GEODUCK

Description: A thick, white clam with coarse, concentric rings on the shell, which is inflated. The valves gape at both ends and are almost rectangular; one end is rounded, the other blunt and almost concave. Length to 180 mm (7 in.). Adults have no noticeable hinge teeth. See Figure 2.

Distribution: Range -- North Carolina to Florida and Texas.
North Carolina -- marine waters from 32 km (20 mi.) N Cape Hatteras to Atlantic Beach; may exist throughout all shallow off-shore North Carolina areas. See Figure 4.

Habitat and Mode of Life: This euryhaline species is presently known from the intertidal zone to 50 m (164 ft.) depth. In mud flats it is known to occur up to a meter (3 ft.) below the surface. Nothing is known about critical habitat for the species.

Status: *Special Concern* . The presence of offshore geoduck-shell beds provides evidence that this species may have been common recently. Robertson (1963) knew of only five live specimens, all collected in an area between NE Florida and Port Isabel, Texas. One living specimen was collected by B. B. Stockard of Greensboro, NC, in the intertidal mud flats of Bird Shoal near Beaufort Inlet on Labor Day, 1956. The bed from which this specimen was taken was destroyed by hurricane "Hazel" in the same year. Valves of this species with ligament attached (indicating a recent living specimen) have been found on North Carolina beaches between Cape Hatteras and Atlantic Beach at rare intervals. Conrad's type specimen, found off Atlantic Beach, is such a specimen.

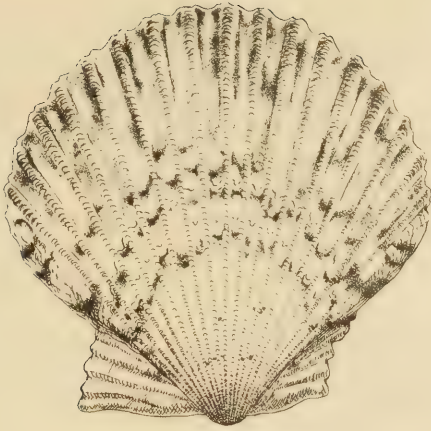


Figure 1. Calico Scallop,
Argopecten gibbus (Linne).
Exterior of upper valve.
Drawing by Leslie Miller.

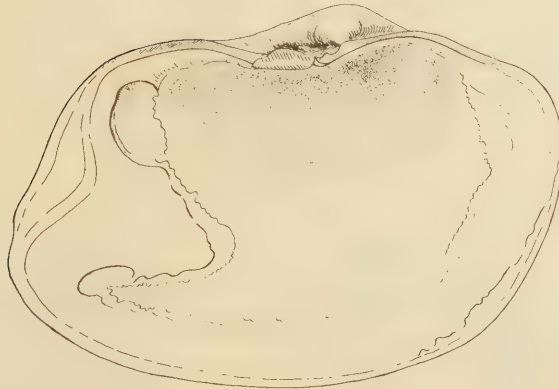
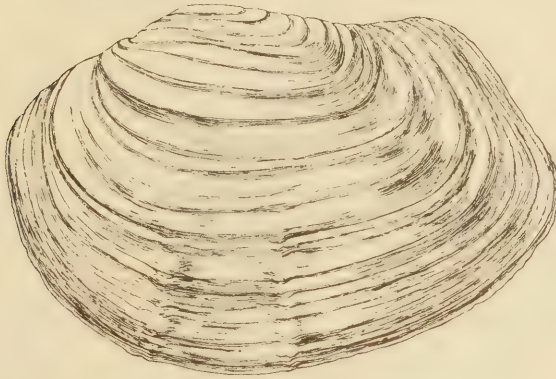


Figure 2. Atlantic Geoduck, *Panopea bitruncata* (Conrad).
A. Exterior of left valve. B. Interior of left valve.
Drawings by Leslie Miller.

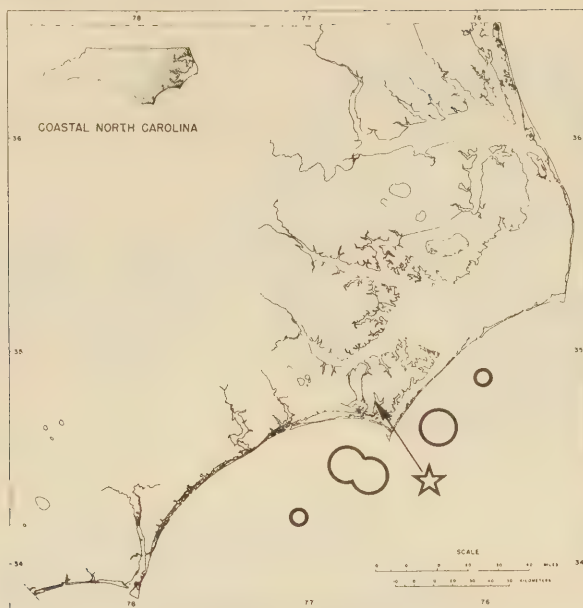


Figure 3. Approximate locations of transitory beds of the Calico Scallop, *Argopecten gibbus*, in North Carolina waters (open circles), and location of the only known state record of the Olive Nerite, *Neritina usnea* (hollow star).



Figure 4. Distribution of the Atlantic Geoduck, *Panopea bitruncata*, in North Carolina. Solid stars indicate locations of recently dead specimens, hollow star of only known live specimen from the state.

Factors causing decline of this species are not known. They may be related to natural changes occurring in the structure of the Outer Banks. Changes in offshore sediment structure could adversely affect larval settlement. No protective measures have been taken, and no research is now being conducted on the species. Exploratory research and monitoring in the offshore areas may determine whether the species is as rare as it presently seems. The Atlantic Geoduck is of scientific interest because of its apparent increasing rarity throughout its known range. It should be pointed out that the closely related *P. generosa* is harvested commercially for its meat in Puget Sound.

References: Robertson, R. 1963. Bathymetric and geographic distribution of *Panopea bitruncata*. Nautilus 76:75-82.

MOLLUSCA; GASTROPODA; NERITIDAE
(Nerites, Bleeding Teeth)

Neritina usnea (Roding) (= *Neritina reclivata* (Say))

OLIVE NERITE

Description: An ovate snail with a large, flattened columella bearing teeth and lacking an umbilicus. The glossy base color is brownish green, and the toothed edge of the columella white. The spire is generally eroded away. The operculum is brownish black and calcareous. It attains a length of 10 to 20 mm (3/8 to 3/4 in.). See Figure 5.

Distribution: Range -- believed to be Florida, Texas, and West Indies.

North Carolina -- one collection, just off US route 70, 5 to 6 km (3 to 4 mi.) N Beaufort, Carteret Co., R. W. Heard, September 3, 1966. (Specimens in U. S. National Museum and UNC Institute of Marine Sciences). Not previously known N of Florida. See Figure 3.

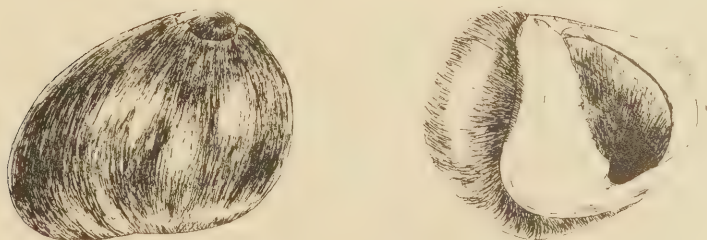


Figure 5. Dorsal (left) and ventral (right) views of the Olive Nerite, *Neritina usnea* (Roding). Drawings by Leslie Miller.

Habitat and Mode of Life: This snail lives in low salinity waters. North Carolina specimens were found living in mud, in water on dead wood, bottles, and other debris, in a marsh area. Molluscan associates were *Melampus*, *Littorina irrorata*, *Detracia floridana*, and unknown hydrobiid snails.

Reproduction: North Carolina specimens were laying eggs in September.

Status: *Special Concern*. Attempts to relocate the population have been unsuccessful, but efforts are being made to find the location of the original collecting site, which is in question. When found, the site and its surrounding area will be closely examined to determine if the species is firmly established in a little known or collected habitat of the state. The extension of the range of this species into North Carolina brackish waters is not understood. The significance of this extension and its possible causes could be important in understanding biological changes occurring within the marine waters of the state, changes which are either natural or man-caused.

The significance of this species to the ecology of brackish marshes of North Carolina is not known. It might occupy a niche not already filled by other animals and thus could contribute to the overall utilization of marsh grasses or detritus. The species is of particular interest to teachers, ecologists, and amateur shell enthusiasts since it is the only member of the Neritidae to have been reported from North Carolina areas, and from low salinity areas north of Florida.

Author: Hugh J. Porter.

MOLLUSCA; GASTROPODA; MELONGENIDAE
(Conchs and Whelks)

Busycon canaliculatum (Linne)

Busycon carica (Gmelin)

Busycon contrarium (Conrad)

CHANNELED WHELK

Knobbed Whelk

LIGHTNING WHELK

Description: These three whelks are relatively large snails which may reach a length of 28 cm (11 in.). They are somewhat pear-shaped, with an aperture almost as long as the shell. The exterior of the shell is rough and sometimes very hairy. The inner surface or aperture may be brightly colored with white, yellow, purple, orange, or dark red. The Channeled Whelk does not have knobs on the shoulder, and live specimens are covered with a hairy growth (periostracum). The Lightning Whelk is strongly knobbed on its shoulder and its aperture is on the left side of the shell. The Knobbed Whelk is also strongly knobbed on the shoulder but has its aperture on the right side of the shell. A subspecies of this form, known as Kiener's Whelk, *B. carica eliceans*, is characterized by a heavy tumid ridge or swelling on the center of the body whorl. It may occur in southern North Carolina localities. Taxonomic confusion

exists between the two forms; geographical races based on morphometric characters may just occur within the Knobbed Whelk form. All three species are pictured in Abbott (1974, pp. 222-223) and Porter and Tyler (1971, p. 32). Gosner (1971, p. 283) provides comparative drawings.

Distribution: Range -- Channeled Whelk: Cape Cod to St. Augustine, Florida. Knobbed Whelk: Cape Cod to Cape Canaveral, Florida. Lightning Whelk: offshore New Jersey to Florida and Gulf region.

North Carolina -- all three occur throughout entire coastal region; in sounds, both Knobbed and Lightning Whelks are found in shallow near-shore areas, while Channeled Whelk seems restricted to deeper channels. From Cape Hatteras N Lightning Whelk may be found only in deeper offshore waters.

Habitat and Mode of Life: There are no reported habitat differences between the three species. They are most frequently found in muddy sand or sandy mud where an abundance of prey bivalves occurs. These include the Atlantic Ribbed Mussel, *Geukensia demissa*; Bay and Calico Scallops, *Argopecten irradians* and *A. gibbus*; Cross-barred Venus, *Chione cancellata*; Disk Dosinia, *Dosinia discus*; Northern and Southern Quahogs, *Mercenaria mercenaria* and *M. campechiensis*; and Stout Tagelus, *Tagelus plebeius*. In North Carolina waters these whelks do not appear to be as serious predators on oysters as they are farther south, but all species can be regarded as serious potential predators of North Carolina's clam beds.

Reproduction: Whelk eggs are enclosed within capsules laid in long strings. Magalhaes (1948) reports that in the Beaufort region strings from the Knobbed Whelk may have up to 154 capsules, with a mean number of 41 eggs per capsule (6,151 eggs in one string). At the time of hatching, one string contained 1,848 young snails. Spawning occurred in the spring and fall. Porter and Schwartz (unpublished data) found egg strings of the Lightning Whelk offshore in Onslow Bay only during early spring in 1972.

Status: *Special Concern.* At present there is no danger that these species will become extinct throughout their ranges. They are of concern here because population levels may become so reduced in certain North Carolina localities that the species might be seriously depleted for long periods. Unconfirmed reports indicate that this is the case with whelk populations in New Jersey waters. Because larval drift is not involved in repopulation of these species, their existing population levels are initially dependent upon the number of native spawning adults. Thus, if over-collecting of live specimens is continued, adult populations could drop below maintenance levels. Cape Lookout, Bird Shoal and parts of Bogue Sound are areas that may be critical. Population levels in the Cape Lookout area seem to have been much reduced in the past decade. Beaches at Cape Lookout and Shackleford and Bogue Banks do not have the number of empty shells that they had just a few years ago.

Population levels need to be monitored, and regulations should be enacted to prohibit collecting of living specimens in critical areas. Although predatory on clams, these whelks present no threat to already

overfished quahog resources. More species of *Busycon* occur in the Cape Lookout area than in any other area of the world, and they form an important feature of our North Carolina marine fauna. Because they are among the largest, most colorful, and reasonably abundant shells on our coast, they are objects of interest to all observers.

References: Abbott (1974), Gosner (1971), Porter and Tyler (1971); see list following introduction.

Magalhaes, H. 1948. An ecological study of snails of the genus *Busycon* at Beaufort, North Carolina. Ecol. Monogr. 18:377-409.

Author: Hugh J. Porter.

MOLLUSCA; GASTROPODA; MELAMPIDAE
(Melampas)

Detracia clarki Morrison

CLARK'S MELAMPUS

Description: A brown snail with spiral bands of white. The shell is subcylindrical and smoothish, with a few spiral incised lines above the shoulder and near the base. There are two strong white teeth on the lower columella. Within the outer lip are several spiral white bands. It attains a length of about 13 mm (1/2 in.).

Distribution: Range — SE Florida and N Cuba (Abbott 1974).
North Carolina — Distribution within the state is unknown; only reported population on NE end of Cedar Island, near ferry slip.

Habitat and Mode of Life: Lives in high intertidal mud flats and is frequently found under driftwood and debris.

Status: *Special Concern.* The first collection of Clark's Melampus in North Carolina was made in 1975 by Morrison, the author of the species. Living specimens were found at the original site in March 1976 by Morrison and Porter. The significance of this record, and the reasons for its present status, are similar to those given for *Neritina usnea*. Future attempts will be made to determine the geographic size of the population.

References: Abbott (1974); see list following introduction.
Morrison, J. P. E. 1951. Two new Western Atlantic species of pulmonate mollusks of the genus *Detracia* and two old ones (Family Ellobiidae). J. Wash. Acad. Sci. 41:17-20.

Author: Hugh J. Porter.

Discussion

Ben Sanders: Could you go into a little more detail on the species that you mentioned at New Bern in the estuary there. I couldn't quite hear ...

Porter: *Rangia cuneata*, the Common Rangia Clam is the species. It has a maximum size of about three and one-quarter inches. Dr. Morrison has considered it as a secondary food species. Raw, the species does not have much flavor, but it is eaten at times. One local dealer, for awhile, soaked the raw meats overnight in a concentrated quahog juice and sold the product to a nationally known food chain. These raw-soaked clams, I thought, had an excellent taste.

Sanders: Their entire known population is there at New Bern?

Porter: No! While a large population is at New Bern and off Flanner's Beach, a large population is also in Pamlico River. The one population which has been fished commercially is in Albemarle Sound. One difficulty about eating the species is that the water in which it is found living may have a swamp or musty flavor. If you open the clams by steaming, this musty flavor is sometimes accentuated. Until something can be done about this flavor, the clam can be considered only as a secondary food source. In nature, I believe, the species is eaten by rays.

Bruce Dornseif: I'd like to know the status of the bay scallops in the *Zostera* beds off North Carolina, whether they are in danger.

Porter: Looks like we have a good population developing this year.

Dornseif: Are they consistent throughout the whole state within the *Zostera* beds?

Porter: I don't know, as I am acquainted mainly with the local area. The commercial population normally occurs between an area near Cape Lookout and Swansboro. I have heard rumors that its range was extending farther south. An interesting fact about the southern distribution of the Bay Scallop, *Argopecten irradians*, is that up until recently it was completely unknown from South Carolina waters.

Rowland Shelley: Is the geoduck found south of North Carolina?

Porter: Yes. Robertson in 1966 published a report stating that the only live-collected specimens of this species had been collected from Florida waters. He was unaware, however, of the one live-collected North Carolina specimen from Bird Shoal. Occasionally specimens are washed up on North Carolina beaches that still have an attached ligament, which would indicate a recently living specimen. Divers have lately found numbers of geoduck shells offshore from Atlantic Beach, where the state sunk a Liberty Ship as part of a sports-fishing reef project. Shell age is not known, but the presence of the shells is a good indication of an earlier major population. A similar geoduck species, commercially harvested on the west coast, will frequently bury itself to a four-foot depth. Possibly we are missing the local population simply because our arms aren't long enough to dig them up. I just don't know.

Marine Fishes

by

Frank J. Schwartz, William W. Hassler, John W. Reintjes,
and Michael W. Street

Introduction

The problem of defining or designating rare and endangered organisms that live on land or in confined aquatic systems is far easier than making such decisions for the inhabitants of open estuarine or ocean systems. In the latter situations a species may be a member of one or more faunal zones, a factor that made the work of this committee far more difficult than it would have been had we been dealing with less continuous systems.

North Carolina is situated on the western Atlantic Ocean near the interface of two or three faunal zones. Fishes of northern or colder water regimes usually occur from Cape Hatteras northward, while southern forms are members of or can be transported into the area by the inshore Carolinian, or offshore Caribbean, water masses. The latter is greatly influenced by the northerly flowing Gulf Stream. Local environmental factors of winds, tides, and currents likewise have direct or subtle roles in determining what species may be within the political boundaries of North Carolina. World climatic and environmental changes also influence the entire North Carolina marine fish fauna.

It was after examination and full realization of the above that the marine fishes committee embarked on the task of designating the endangered and threatened forms of North Carolina. Problems of category definition arose, too, for there were differences in those available to us or within those used by each committee member. We had to decide whether to go by the strict definitions of Miller (1972), the IUCN Redbook (1969), or the definitions suggested by the Steering Committee for this Symposium. We decided to adopt variations of these as they best applied to the marine species. One notable addition is use of the designation *Depleted*, since marine stocks are widely exploited commercially.

Other problems that arose had to do with those species known by only one or a few specimens in North Carolina but abundant elsewhere, those known only seasonally, and range extension records. For those forms whose southern or northern range extended to North Carolina we evaluated their total population status. This procedure permitted us to eliminate 200 to 300 species from consideration, fishes with northern range limits here like tarpon, snook, ladyfish, and others. Also, a number of species were simply seasonal transients or chance occurrences as a result of water temperatures warming or cooling. Examples in part would be bumpers, some snappers, and other fishes. This also eliminated forms that were regular components of oceanic habitats, but which occurred accidentally or sporadically after water mass shifts. Examples would be deep-sea fishes and some flying fishes.

Out task in evaluating status also extended to examining the direct or indirect effects of man's activities on marine fishes. Given that we have drastically altered the estuaries and possible food sources for such fishes as sturgeons and herrings, were these species really rare, endangered, threatened, or what? Was man's increased offshore fishing efforts

altering the distributions and abundance of anadromous or inshore estuarine-dependent species which use the open ocean for spawning? Was the sporadic occurrence of a species in North Carolina the result of our inability to catch the species, a function of sampling technique, frequency, and other factors? Should the fact that a species was considered endangered or rare elsewhere, e.g. bluefin tuna, influence our decision concerning the species in North Carolina?

For those species that have declined drastically in recent years we also considered present populational levels before deciding their status. The fact that a species still existed or contributed a quantity of fish to commercial and recreational catches did not necessarily remove it from our list, for several of the species noted (sturgeon, herrings) do maintain themselves, although at lower levels than in previous years. These lower levels of abundance may be so near the species' threshold of survival that a slight shift, induced by man or nature, could place it in jeopardy.

In other cases our knowledge about certain species, whether in North Carolina or elsewhere, was so meager that we decided to list them until systematic, biological, and ecological information can be gathered and questions resolved. Until we know how these species fit into the overall fauna of North Carolina we should make every effort to protect them. Much more research is needed before judgements can be made as to whether such species are at a momentary low level of abundance, are transients or faunal stragglers, and whether they and their habitats need protection.

With respect to habitats, we strongly urge that the lower Cape Fear and Outer Banks areas of North Carolina be managed properly, and sanctuaries be set aside for the species of concern. Every effort should be made to stabilize, rehabilitate, and rejuvenate all habitats of anadromous and estuarine-dependent species within North Carolina. We further urge that all attempts be made to protect the Continental Shelf and its immediate and adjacent environs to assist estuarine-dependent species in their use of this habitat. We recommend that an early alert system be established to call attention to species that may become endangered in the future, and to note recoveries of species here listed as in some category of concern. We further recommend that this committee continue its labors in this direction.

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Marine Fishes -- Species List and Accounts

Species List

Species	Status
Osteichthyes	
Acipenseridae	
<i>Acipenser brevirostrum</i> , Shortnose sturgeon 252	Extirpated?
<i>Acipenser oxyrinchus</i> , Atlantic sturgeon 254	Depleted
Clupeidae	
<i>Alosa aestivalis</i> , Blueback herring 255	Depleted
<i>Alosa pseudoharengus</i> , Alewife 256	Depleted
<i>Alosa sapidissima</i> , American shad 257	Depleted
Cyprinodontidae	
<i>Fundulus confluentus</i> , Marsh killifish 258	Special Concern
<i>Fundulus luciae</i> , Spotfin killifish 259	Special Concern
Blenniidae	
<i>Blennius marmoreus</i> , Seaweed blenny 260	Special Concern
<i>Hypleurochilus geminatus</i> , Crested blenny 260	Special Concern
<i>Hypsoblennius ionthas</i> , Freckled blenny 261	Special Concern
Gobiidae (Eleotridae)	
<i>Dormitator maculatus</i> , Fat sleeper 262	Special Concern
<i>Eleotris pisonis</i> , Spinycheek sleeper 262	Special Concern
<i>Evorthodus lyricus</i> , Lyre goby 263	Special Concern

SPECIES ACCOUNTS

PISCES; ACIPENSERIFORMES; ACIPENSERIDAE
(Sturgeons)

Acipenser brevirostrum Lesueur

SHORTNOSE STURGEON

Description: A dark-bodied fish dorsally, light ventrally, which grows to a length of just over a meter (40 in.) and a weight of 4 kg (9 lb). The snout is pointed, with inferior mouth, and the tail is heterocercal (upper lobe much longer than lower). There are five rows of horny scutes along the body, with a single or paired row of shields behind the dorsal fin. The snout in adults is shorter than the postorbital distance, but in young is longer than this distance. This species may be distinguished from the Atlantic sturgeon by its smaller maximum size, wider mouth (69 to 81% of interorbital width as opposed to 55% or less), pre-anal shields in a single row instead of double, and blackish viscera. See Smith (1907, p. 58) and Greeley (1937) for illustrations.

Distribution: Range -- only viable populations appear to be in Hudson River, with a few reported for St. John River, New Brunswick; Nova Scotia; and Kennebec-Sheepscot River, Maine. A number of specimens have been reported from Altamaha River, Georgia (Dahlberg, pers. comm.). Once known along Atlantic coast from New Brunswick, Canada, to Florida.

North Carolina -- unconfirmed reports from offshore; once sporadically known from Albemarle and Pamlico sounds, and other North Carolina waters, but today believed extirpated.

Habitat and Mode of Life: The shortnose sturgeon occurs in fresh, brackish, or salt water, most frequently in tidal rivers. It is a bottom feeder on small animals and plants.

Reproduction: The species ascends rivers to freshwater to spawn in early spring when about 50 cm (20 in.) in length. Ripe eggs are dark brown but the number is unknown. Confusion with young of the Atlantic sturgeon has diminished our knowledge of the biology, numbers, and other aspects of this species.

Status: Probably *Extirpated*. The shortnose sturgeon is considered *Endangered* throughout its range by the U. S. Fish and Wildlife Service and the International Union for the Conservation of Nature. Habitat destruction by man and overfishing are the main causes of decline. Its relatively small size and low egg productivity make the fish less desirable than the Atlantic sturgeon, although its flesh is tasty.

- References: Smith (1907); see list following introduction.
- Gorham, S. W., and D. E. McAllister. 1974. The shortnose sturgeon, *Acipenser brevirostrum*, in the Saint John River, New Brunswick, Canada, a rare and possibly endangered species. *Syllogeus* 5:1-18.
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- Jordan, D. S. 1886. Notes on fishes collected at Beaufort, N. C., with a revised list of the species known from that locality. *Proc. U. S. Nat. Mus.* 9:25-30.
- Magnin, E. 1963. Notes sur la repartation, la biologie et partierliement la croussince de l'*Acepenser brevirostris* Le Sueur 1817. *Le Natureliste Can.* 90:87-96.
- McCleave, J. D., and S. M. Fried. 1974. Three unusual shortnose sturgeon (*Acipenser brevirostrum*) from Montsweag Bay, Maine. *Can. Field Nat.* 88:359-360.
- Yarrow, H. C. 1877. Notes on the natural history of Fort Macon, North Carolina, and vicinity. No. 3, Fishes. *Proc. Acad. Nat. Sci. Phila.* 29:203-218.

Description: A large gray or brown fish dorsally and whitish ventrally. The snout is pointed, with inferior mouth, and the tail is heterocercal. Females grow to a length of 4.2 m (14 ft.) and males to 2.1 m (7 ft.), and the species attains weights of about 360 kg (800 lb). Recent North Carolina specimens of 2.5 m (8 1/2+ ft.) and 171 kg (380 lb) have been taken, and a former size of 3.6 m (12 ft.) and 225 kg (500 lb) was once recorded at Hatteras. There are five separated rows of horny scutes along the body, and the shields behind the dorsal fin are paired. The preanal shields are in a double row. The snout of adults is shorter than the postorbital distance, while that of young is longer. The mouth is narrow, less than 55% of the interorbital width, and the viscera are unpigmented. See Smith (1907, p. 56, Plate 2 opp. p. 8) for illustrations.

Distribution: Range -- common Labrador to Florida.

North Carolina -- along coast, but best fisheries at Drum, Ocracoke, and Bogue inlets. Occurs in most rivers and sounds all year, especially in Neuse and Cape Fear rivers and Albemarle and Pamlico sounds.

Habitat and Mode of Life: The Atlantic sturgeon is an anadromous species which migrates into freshwater for spawning in late spring and summer, when water temperatures are 13.5 to 18° C (56 to 64° F). It feeds on mollusks and other bottom organisms, including small fishes, and vegetation. Although a bottom feeder, it can often be seen jumping on spawning runs, and does not feed at this time.

Reproduction: Spawning occurs in freshwater, and a single female may lay up to 3.7 million eggs. The eggs are demersal (sinking to the bottom), light to dark brown in color, and 2.5 mm (1/8 in.) in diameter. The outside membrane sticks to the substrate, and there is no parental care. Females must be about 67 kg (150 lb), 2.4 m (8 ft.) long, and 10 years old to spawn. They live at least 18 years. Males are 31.5 kg (70 lb) and 1.5 to 1.8 m (5 to 6 ft.) long at spawning.

Status: *Depleted*. The total North Carolina catch in 1880 was around 437,000 lb, and 134,125 lb in 1902. Smith (1907) stated that, "It is incumbent on the state to take prompt and radical measures to prevent the further diminution in the supply of this excellent fish, and to restore it to something like its original abundance, if this is now possible." The current population is maintaining itself at a comparatively low level, yielding about 45,000 lb in 1975. Habitat destruction (dredging, channelization) and pollution have reduced the bottom fauna on which this fish feeds, and altered substrates on which it spawns. Navigation locks and dams may have an effect on spawning migrations in the upper Cape Fear River.

References: Smith (1907); see list following introduction. Chestnut, A. F., and H. S. Davis. 1975. Synopsis of marine fisheries. Univ. N. C. Sea Grant Pub. SG-75-12, Raleigh, NC. 425 pages.

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PISCES; CLUPEIFORMES; CLUPEIDAE
(Herrings)

Alosa aestivalis (Mitchill)

BLUEBACK HERRING

Description: The blueback herring is a generally silvery fish, especially ventrally, with a bluish dorsum and a greenish luster to the sides and gill covers. As with other clupeids, the body is compressed. Individual weights seldom exceed 220 g (1/2 lb). There are silvery, deciduous (falling away, easily removed) scales on the slender body. The peritoneum (body cavity lining) is almost always dark. The eye is smaller than the snout length. For a color illustration see Smith (1907, Plate 4).

Distribution: Range -- along Atlantic coast from Nova Scotia to Tomoka River, Florida.

North Carolina -- anadromous, migrating throughout most coastal rivers from sea to freshwater to spawn; greatest density in Albemarle Sound area.

Habitat and Mode of Life: An anadromous fish which begins ascending rivers in December or January, and by May spawns in freshwater. It is a planktonic feeder.

Reproduction: Spawning occurs in great numbers in rivers and streams, from just above tidewater to the Fall line. Each female may produce 100,000 to 400,000 eggs. The eggs are small, about 1 mm, and adhere to debris, pilings, stones, and other objects. Pound nets, the principal commercial gear, are often coated with eggs during the peak of the spawning season.

Status: *Depleted.* The blueback herring composes about 90% of "alewife" or "river herring" landings in North Carolina. While landings were fairly stable for many years, reaching an all-time peak of more than 19 million lb in 1969, catch has declined to less than 6 million lb in 1975 as a result of overfishing by foreign vessels on high seas. While not in danger of extinction, further exploitation, pollution, channelization, and construction of dams on spawning streams may result in further

depletion or even demise of the species. Restrictions have been placed on the high seas fisheries of Poland and the USSR by agreements which should reduce their catches of this fish. Other nations, however, could easily replace the treaty countries and maintain the current level of exploitation. Three sets of locks on the Cape Fear River are operated regularly every spring to facilitate the upstream migration of anadromous fishes. Artificial propagation is fairly simple, but probably not economically feasible on a scale that might be required to support the fishery.

References: Smith (1907), Street and Hall (1973); see list following introduction.

Pate, P. P., Jr. 1974. Age and size composition of commercial catches of blueback herring and alewife in Albemarle Sound, North Carolina and tributaries. Proc. 27th Ann. Mtg. S. E. Assoc. Game Fish Comm.:560-569.

Alosa pseudoharengus (Wilson)

ALEWIFE

Description: A very silvery, deep-bodied fish with large eyes. The back is gray, especially the anterior. Weights seldom exceed 220 g (1/2 lb). The peritoneum is light to slightly mottled. See Smith (1907, Plate 3) for a color illustration.

Distribution: Range -- Atlantic coast from Gulf of St. Lawrence to southern North Carolina.

North Carolina -- anadromous, ascending most coastal streams; enters Lake Mattamuskeet.

Habitat and Mode of Life: The alewife spends its adult life in the sea, ascending rivers in great numbers in spring to spawn in freshwater. The young spend their first year in rivers, moving down and out to sea between November and January, depending on water temperatures. The species is a planktonic feeder.

Reproduction: Spawning runs of this fish generally precede those of other clupeids, and it often migrates all the way to the small, shallow headwaters of streams. Fecundity is reported to average 100,000 eggs per female, but is probably higher. The adherent eggs are laid on the substrate.

Status: *Depleted.* The alewife composes 10% of "river herring" landings, primarily in the Albemarle Sound area. Population declines appear to be greatest in North Carolina and Chesapeake Bay, while in New England they may be increasing because of management efforts. Depletion caused by the foreign offshore trawl fishery was significant during the late 1960's and early 1970's. While still abundant and in no danger of immediate extirpation, pollution, construction of dams, channelization, and overfishing on spawning streams or offshore will seriously affect the species. Three locks in the Cape Fear River are regularly operated every spring to permit upstream movement. Artificial propagation is simple, but not economically feasible to maintain the species. Foreign fishing treaty restrictions apply equally to this species.

References: Smith (1907), Street and Hall (1973); see list following introduction.

Pate, P. P., Jr. 1974. Age and size composition of commercial catches of blueback herring and alewife in Albemarle Sound, North Carolina and tributaries. Proc. 27th Ann. Mtg. S. E. Assoc. Game Fish Comm.:560-569.

Tyus, H. M. 1971. Population size, harvest, and movements of alewives *Alosa pseudoharengus* (Wilson) during spawning migration to Lake Mattamuskeet, North Carolina. Unpub. PhD dissert., N. C. State Univ., Raleigh, NC. 77 pages.

Alosa sapidissima (Wilson)

AMERICAN SHAD

Description: The American shad is the largest of the herrings, with average weights of 1.3 to 2.3 kg (3 to 5 lb.) and maxima of 5 to 6.3 kg (11 to 14 lb.). It is silvery below and on the sides with a bluegreen back. One or two rows of dusky spots are on the upper sides of the body behind the operculum (gill cover). See Smith (1907, Plate 5) for a color illustration, and Schwartz and Tyler (1970, pp. 6-7) for drawings and other information.

Distribution: Range -- Atlantic coast from S Newfoundland to Tomoka River, Florida.

North Carolina -- anadromous, ascending most coastal streams to spawn in freshwater.

Habitat and Mode of Life: This species spends most of its adult life in the ocean. Beginning in December it ascends streams to spawn in or near freshwater by June. The young spend their first year in estuaries, moving down and out to sea as waters turn cold. It is primarily a planktonic feeder, occasionally eating small fish such as anchovies.

Reproduction: Spawning females produce 100,000 to 500,000 eggs, which drift near the bottom.

Status: *Depleted.* During the late 1800's and early 1900's this fish was North Carolina's most valuable fishery resource. Approximately 9 million lb was taken in 1897, but there has been a recent sharp decline to less than 350,000 lb annually. Artificial propagation techniques are well known and were extensively practiced between 1895 and 1940, but with no improvements in species stock. Pollution, dam construction, and overfishing have led to the current decline. Stream channelization above Jacksonville, North Carolina, has essentially eliminated all anadromous fishes from the entire New River.

References: Smith (1907), Street and Hall (1973); see list following introduction.

Nichols, P. R., and D. E. Louder. 1970. Upstream passage of anadromous fish through navigation locks and use of the stream for spawning and nursery habitat, Cape Fear River, N. C. 1962-66. U. S. Fish Wildl. Circ. 352:1-12.

Schwartz, F. J., and J. Tyler. 1970. Marine fishes common to North Carolina. N. C. Dept. Cons. Devel., Raleigh, NC. 32 pages.

Walburg, C. H. 1957. Neuse River shad investigations, 1953. U. S. Fish Wildl. Serv., Spec. Sci. Rep. Fish 206, 13 pages.
_____, and P. R. Nichols. 1967. Biology and management of the American shad and status of the fisheries, Atlantic coast of the United States, 1960. U. S. Fish Wildl. Serv., Spec. Sci. Rep. Fish 550, 105 pages.

PISCES; ATHERINIFORMES; CYPRINODONTIDAE
(Killifishes)

Fundulus confluentus Goode and Bean

MARSH KILLIFISH

Description: A small, elongate fish measuring about 65 mm (2 1/2 in.), with a slightly superior mouth. There are 10 or 11 rays in the dorsal fin. The general color is brownish or yellowish. Males have 13 black cross bars on the body. Females are laterally marked with obvious but irregular dots and lighter, lengthwise streaks. There is a black ocellus or "eyespot" on the posterior rays of the dorsal fin. Both sexes are pictured in Eddy (1957, p. 172).

Distribution: Range -- Maryland to Key West, Florida, west to Alabama.

North Carolina -- one old record Hatteras, Dare Co., 1927; recent records Mullet Pond, Shackleford Banks, and marshes of Newport River, Carteret Co.

Habitat and Mode of Life: This is a species of slow to stagnant rivers and ponds, preferring fresher waters to high saline areas. It feeds on crustaceans, insects, mollusks, worms, and vegetation.

Reproduction: Females mature at about 60 mm (2 3/8 in.), and are gravid from April until September. The adhesive eggs are buried in pods of 50 to 100 in peaty substrates. They can withstand long periods of desiccation as long as they are damp, and will hatch after renewed rains flood an area.

Status: *Special Concern*. The species is presently restricted to only a few areas. These have apparently not yet been affected by man.

References: Eddy, S. 1957. How to know the freshwater fishes. W. C. Brown Co., Dubuque, IA. 253 pages.
Harrington, R. W., Jr. 1959. Delayed hatching in stranded eggs of marsh killifish, *Fundulus confluentus*. Ecology 40(3):430-436.
Menhinick, E. F., T. M. Barton, and J. R. Bailey. 1974. An annotated checklist of the freshwater fishes of North Carolina. J. Elisha Mitchell Sci. Soc. 90(1):24-50.
Schwartz, F. J. 1970. Fishes and changing ecology of Mullet Pond, a barrier beach island pond on Shackleford Banks, North Carolina. J. Elisha Mitchell Sci. Soc. 86(1):31-34.

Fundulus luciae (Baird)

SPOTFIN KILLIFISH

Description: A diminutive species ranging in length from 22 to 40 mm (7/8 to 1 1/2+ in.). The body is elongate, with a slightly superior mouth. There are 8 rays in the dorsal fin. Females are grayish green dorsally and lighter on the lower sides and venter. The dark eye has a narrow golden band, and there is a brownish blotch on the gill cover. The fins are yellowish or tan. Males are olive or greenish dorsally, with yellowish sides and darker crossbars. The abdomen is orangish. The fins of the male are variable in color, being yellowish brown, pink, or orange. There is a dark ocellus on the posterior dorsal rays. Young are colored like females. Both sexes are pictured in Hildebrand and Schroeder (1927, p. 144).

Distribution: Range -- sporadic in Delaware, Georgia, North Carolina, and Virginia.

North Carolina -- known from three specimens from marshes of Bogue Sound near Ft. Macon, Carteret Co., 1974.

Habitat and Mode of Life: This species frequents muddy shallows near *Spartina* marshes, and tolerates a variety of salinities and water temperatures. It feeds on small crustaceans, mollusks, and worms.

Reproduction: Reported by Hildebrand and Schroeder (1927) to spawn from April to October at Beaufort. The eggs are 2 mm (1/16 in.) in diameter. Breeding habits are similar to those of the marsh killifish.

Status: *Special Concern*. The species is known from so few specimens in North Carolina and elsewhere that alteration of the coastal marshes by man may cause its extirpation.

References: Hildebrand, S. F. 1916. The U. S. Fisheries Biological Station at Beaufort, N. C. during 1914 and 1915. Science N. S. 43(1105):303-307.

Hildebrand, S. F., and W. C. Schroeder. 1927. Fishes of Chesapeake Bay. Bull. U. S. Bur. Fish. Vol. 43, Part I, Washington, DC. 366 pages.

Jorgenson, S. C. 1970. A Georgia record for the cyprinodontid fish, *Fundulus luciae*. Chesapeake Sci. 10(1):65.

Miller, G. L., and S. C. Jorgenson. 1969. Seasonal abundance and length frequency distribution of some marine fishes in coastal Georgia. U. S. Fish Wildl. Serv. Data Rep. 35, 102 pages.

Schwartz, F. J. 1970. Fishes and changing ecology of Mullet Pond, a barrier beach island pond on Shackleford Banks, North Carolina. J. Elisha Mitchell Sci. Soc. 86(1):31-34.

PISCES; PERCIFORMES; BLENNIIDAE
(Combtooth Blennies)

Blennius marmoreus Poey

SEAWEED BLENNY

Description: A small fish of about 60 mm (2 in.), with an oblong, compressed and naked body. The head is short with a blunt, rounded profile. There are short canine fangs in the lower jaw, the gill opening is wide, and the membrane is free from the isthmus. The eye is large, twice the snout length, and the posterior nostril has a tube. An orbital cirrus or fringe is divided into three branches. The taxonomy of this fish is unclear, and several species may actually be involved.

Distribution: Range -- New York to Venezuela, but northern or other specimens may be other species.

North Carolina -- depending on species determination, known from rock jetties located in Carteret Co.

Habitat and Mode of Life: This species is an associate of rock jetties, and it is apparently carnivorous.

Reproduction: The reproductive habits of the Seaweed blenny are unknown, but suspected to be similar to other blennies (see following accounts).

Status: *Special Concern*. Although specific identity is unclear, efforts should be made to protect the known population and its habitat.

References: Böhlke, J. E., and C. C. G. Chaplin. 1968. Fishes of the Bahamas and adjacent tropical waters. Livingston Publ. Co., Wynnewood, PA. 771 pages.
Radcliffe, L. 1914. The work of the U. S. Fisheries Marine Biological Station at Beaufort, N. C., during 1913. Science N. S. 40(1029):413-417.

Hypleurochilus geminatus (Wood)

CRESTED BLENNY

Description: A small fish of about 65 mm (2 1/2 in.), with a somewhat elongate, naked body and snubnosed head. There is a long canine tooth in the rear of both jaws. The gill membranes are broadly joined to the isthmus. Males have a high suborbital crest, and a large tentacle or cirrus over the eye, with four smaller branches at its base. The taxonomic status of this fish is unresolved, and two or more species could be represented.

Distribution: Range -- Cape Lookout, North Carolina, southward to Brazil and N Gulf of Mexico.

North Carolina -- poorly known, but apparently throughout estuarine and high salinity areas, associated with pilings or fouling organisms.

Habitat and Mode of Life: The crested blenny is associated with oysters, clams, sponges, and attached fouling organisms, and feeds on

microorganisms. It is an inquisitive and aggressive territorial fish.

Reproduction: Spawning occurs May to October, and the eggs, attached to objects among which the adults live, receive parental care. They are opaque with purple and orange spots within the yolks. Development and hatching occur in 6 or 7 days at 26 to 28° C. Hatchlings can be confused with *Hypsoblennius hentzi*, which has a very blunt forehead, a prominent bony ridge over and in advance of the eye, large preopercular spines, and more black on the pectoral fins. The larvae are pelagic and live near the surface prior to moving to a bottom existence.

Status: *Special Concern*. Habitats of this species can be easily destroyed by pollution or modification.

References: Hildebrand, S. F., and L. E. Cable. 1938. Further notes on the development and life history of some teleosts at Beaufort, N. C. Bull. U. S. Bur. Fish. 48(24):506-642.

Hypsoblennius ionthas (Jordan and Gilbert)

FRECKLED BLENNY

Description: A small, somewhat elongate, scaleless fish with a short, blunt head. The mouth is small and low, and lacks posterior canine teeth in the jaws. The gill opening extends to the middle of the pectoral fin base. The eye is large, and the cirrus over the eye is short and not bifurcated. The taxonomy is confused, and three separate species may be involved.

Distribution: Range -- North Carolina to Florida and N Gulf of Mexico.

North Carolina -- known sporadically from lower Cape Fear River near Southport.

Habitat and Mode of Life: Similar to the crested blenny.

Reproduction: Unknown, but suspected to be similar to other blennies.

Status: *Special Concern*. The freckled blenny is a very recent discovery in the state, and virtually nothing is known of the species anywhere in its range.

PISCES; PERCIFORMES; GOBIIDAE (ELEOTRIDAE)
(Sleepers)

Dormitator maculatus (Bloch)

FAT SLEEPER

Description: A robust fish with a short, heavy body, attaining a length of 23 to 30.5 cm (9 to 12 in.). The color is black with light spots. There is a large, black blotch on the body above the upper angle of the operculum, and a dark vertical bar at the base of the pectoral fins. The caudal fin is rounded, and the pelvic fins are broad and separated. There are 7 dorsal spines and 14 pectoral rays. Smith (1907, p. 364) provides a line drawing.

Distribution: Range -- North Carolina to Brazil; Bahamas and West Indies.

North Carolina -- previously known from three early collections, one at Wilmington, two near Beaufort, with the latter apparently its northernmost locality. Currently known only from specimens taken in lower Cape Fear River just N Southport.

Habitat and Mode of Life: This fish is common in marsh areas of lower saline estuaries, and also occurs in sounds and freshwaters. Its habits are typical of gobioid fishes, and it feeds on bottom organisms associated with fouling.

Status: *Special Concern*. The only locality where this species is known to be abundant is in the newly formed Carolina Power and Light Company Brunswick Power Plant intake canal, just north of Southport.

References: Smith (1907); see list following introduction.
Dawson, C. E. 1969. Studies on the gobies of Mississippi Sound and adjacent waters. II. An illustrated key to the gobioid fishes. Gulf Coast Res. Lab. Mus. Pub. 1. 59 pages.
Hildebrand, S. F. 1941. An annotated list of salt and brackish water fishes, with a new name for a menhaden, found in North Carolina since the publication of "The Fishes of North Carolina" by Hugh M. Smith in 1907. Copeia No. 4:22-232.

Eleotris pisonis (Gmelin)

SPINYCHEEK SLEEPER

Description: A rather elongate fish reaching lengths of 15 to 17.5 cm (6 to 7 in.). The body is brown and the mouth large. The pelvics separate into cupshaped fins. The species gets its name from a strong, concealed spine on the preopercle. The scales of the head, predorsal area, chest, and abdomen are cycloid (with a free margin), but the body scales are ctenoid (with a toothed margin). There are 6 dorsal spines and 17 pectoral rays.

Distribution: Range -- North Carolina, and along Gulf of Mexico.
North Carolina -- recent captures in lower Cape

Fear River.

Habitat and Mode of Life: This is a species of low saline waters, frequently abundant in muddy marsh areas and ponds of upper estuaries. It also occurs in freshwater. Primary foods are probably bottom organisms.

Reproduction: The reproductive habits are unknown but suspected to be similar to those of other sleepers and gobies.

Status: *Special Concern.* Practically nothing is known of the exact distribution and biology of this species in North Carolina.

References: Dawson, C. E. 1962. Studies on the gobies of the Mississippi Sound and adjacent waters. II. An illustrated key to the gobioid fishes. Gulf Coast Res. Lab. Mus. Pub. 1, 59 pages.

PISCES; PERCIFORMES; GOBIIDAE
(Gobies)

Evorthodus lyricus (Girard)

LYRE GOBY

Description: An elongate, scaled fish with a large head, attaining a length of 57 mm (2 1/4 in.). The mouth is mullet-like, low on the head, and usually has some large canine-like teeth. The pelvic fins are united to form an adhesive disk. There are two obvious caudal spots, which usually have a narrow connection. The dorsal spines number six, and the first dorsal fin elements are elongate, sometimes reaching the caudal peduncle (tail base) in males. A photograph is provided by Dahlberg (1975, p. 173).

Distribution: Range -- Chesapeake Bay south to West Indies, Gulf of Mexico, and Surinam.

North Carolina -- known from three specimens, two (UNC 3837) captured Morehead City, Bogue Sound, 19 November 1963, and one (UNC 9439) captured Pamlico Sound, 3.2 km N Hatteras Inlet, 16 April 1974.

Habitat and Mode of Life: The lyre goby is a fish of shallow waters near *Spartina* marshes. It is found in soft mud and oyster shells.

Reproduction: Nothing is known about its reproductive habits, but they are believed to be similar to those of other gobies.

Marine Fishes -- Accounts Special Concern

Status: *Special Concern*. Since so few specimens are known, and *Spartina* marshes are constantly being altered and filled by man, this species deserves special consideration.

Remarks: The species was earlier described as *Mugilostoma*.

References: Dahlberg, M. D. 1975. Guide to Coastal Fishes of Georgia and Nearby States. Univ. Ga. Press, Athens, GA. 186 pages.
Dawson, C. E. 1969. Studies on the gobies of Mississippi Sound and adjacent waters. II. An illustrated key to the gobioid fishes. Gulf Coast Lab. Mus. Pub. 1, 59 pages.
Hildebrand, S. F., and W. C. Schroeder. 1927. Fishes of Chesapeake Bay. Bull. U. S. Bur. Fish., Vol. 43, Part 1, Washington, DC. 366 pages.

Freshwater Fishes

Introduction

by

Joseph R. Bailey

The combined efforts of academic and state ichthyologists and fisheries biologists over the last three decades have brought our knowledge of species composition and distribution of the North Carolina freshwater fish fauna to a moderately refined state. We are aware of a few still-to-be-described species, and a few important taxonomic problems remain to be clarified. Additional refinements are expected to continue for some years to come, but on the whole we may consider the fauna well known.

It is a large and diverse fauna of about 200 species, not including those marine forms which enter estuaries and the lower courses of coastal streams but are not dependent on fresh water for survival. The size and diversity of the fauna reflects the number and arrangement of major water courses in the state. The highlands of western North Carolina include the highest elevations of eastern United States, hence streams flow from them in all directions (Figure 1).

In the north the venerable New River flows into the Kanawha, thence to the Ohio and Mississippi Rivers to the Gulf of Mexico. Major falls along the upper reaches of this course, combined with consequent long isolation, has permitted the evolution of a sizeable distinctive fauna in these headwaters. To the west six North Carolina rivers -- the Watauga, Nolichucky-Toe, French Broad, Pigeon, Little Tennessee, and Hiwassee -- are tributary to the Tennessee River. This again joins the Ohio-Mississippi system enroute to the Gulf. The tremendous, sprawling Mississippi system and its tributaries harbors the largest freshwater fish fauna outside the tropics, and the Tennessee, with its headwaters in North Carolina, shares this bounty.

To the south six more major North Carolina streams -- the Savannah, Broad, Catawba, Yadkin, Lumber, and Waccamaw rivers -- flow across Georgia and South Carolina into the Atlantic Ocean. The first four head from the eastern slopes of the Blue Ridge, and the last two drain the Sand Hills and swamps of our southeastern corner, providing another distinctive faunal cluster of species, including some endemics.

Three major rivers in the state flow southeastward to the Atlantic entirely within our borders -- the Cape Fear, Neuse, and Tar. These contribute two additional endemic species. Also flowing southeastward, but this time originating in Virginia and crossing North Carolina, are two rivers entering the Atlantic through Albemarle Sound -- the Roanoke and Chowan. The Roanoke, rising in the mountains, has the richest fauna of all rivers of our Atlantic seaboard. One of its major tributaries, the Dan, dips into north central North Carolina for some distance before joining the Roanoke, bringing with it still another cluster of endemic and peripheral species into our fauna. The Roanoke itself is a North Carolina river below Kerr Reservoir, contributing important anadromous fishery resources to the state. The Chowan River, rising in the Virginia Coastal Plain, makes a short passage through our northeastern corner before emptying into Albemarle Sound.

Many other smaller streams contribute independently to the extremely complex system of estuaries and sounds of North Carolina, but they are not enumerated here as they contribute no distinctive elements. Their faunas are similar or depauperate examples of the major streams nearest them. However, they may have played significant roles in developing the distributional patterns which evolved in late geological times. Fluctuations in sea level, including depression of the Atlantic by as much as 90-120 meters or more (300-400 or more feet), are known to have taken place during the Ice Age. Combined with periods of high water and the temporary influence of hurricanes and abnormal tides, this created conditions of alternating contact and isolation for the freshwater faunas of the lower Coastal Plain. The recency of these events has prevented fragmentation of the coastal fauna into distinctive elements.

Watersheds tend to have faunal elements which are distinctive one from the other, but internally homogeneous. Thus, each contains a faunal unit which may be affected as an assemblage by environmental changes. These may have occurred eons ago as natural geological processes modified the environment, and created, isolated, impounded, or drained earlier aquatic systems. Human activity now imposes even more drastic changes on our historic stream patterns. Because of this unity we have chosen to treat the freshwater fishes of North Carolina by watersheds in the belief that as the watershed goes, so goes its fauna. A healthy watershed will support a healthy, balanced fauna. A polluted or severely modified system will reflect changes through loss of diversity and imbalance. Evidence that this is true is abundant in examples from our state waters.

In identifying the fragile elements in the North Carolina freshwater fish fauna, the committee examined species lists prepared for each watershed and discussed, species by species, those in any way considered to occupy a precarious position. Our deliberations identified 50 species, or approximately 25% of the state's total fauna, as fitting into one of four recognized categories. Since our criteria may have differed somewhat from those used by colleagues on other committees, a few words of explanation or definition are in order. The categories express our estimation of status in North Carolina, without regard for extralimital status or distribution. A few species have been assigned to different categories on the basis of their status in a given watershed, but this has been kept to a minimum.

Extirpated. If conclusive evidence existed that a species occurred in a watershed sometime in the past, but there are no recent records (since state surveys were undertaken following World War II), the species was presumed *Extirpated*. This does not eliminate the possibility that small populations may persist in favored situations, or that individuals may re-enter state boundaries from elsewhere. Most species in this category occurred in the watershed of the French Broad River.

Endangered. These are rare species with small populations, usually of limited geographic distribution and/or ecological restriction. Some may have already become *Extirpated*. A few are long missing species which have recently been rediscovered.

Threatened. These are species for which we can foresee a real threat of extinction in the near future if their restricted habitats are permitted to deteriorate, or if impoundments which are now contemplated are built. Elements of the New River, Dan River, and Lake Waccamaw faunas

are chief among this category. *Threatened* species may be abundant and thriving at the present, but their ecological requirements are tenuous to the extreme.

Special Concern. This is the largest category and is really a catch-all which defies precise definition. Included are formerly abundant species now markedly declining and perhaps soon to become candidates for a higher category. Others are species of such limited geographic distribution (usually within a single watershed) that any important local environmental change could seriously affect them. A few are very rare but widespread. The majority, perhaps, are species endemic to the state, or to a watershed shared by a neighboring state in which they are of equally limited distribution. Where unique species exist it is our "special concern" to look after them

We have not used the *Undetermined* category, although any aquatic biologist will know that there is much to be learned of the ecology and population dynamics of even our most common and widespread species. In only a few cases do we know with certainty the causes of dwindling populations and final disappearance of a species. We do know that one of the first indications of environmental degradation is reduction in *biotic diversity*, although biomass may remain the same or even increase.

Individual accounts are provided only for species considered *Extirpated*, *Endangered*, or *Threatened*. The descriptions in these accounts are not meant to provide a complete means of positive identification, but to indicate the type of fish involved. Sources of more specific information are indicated. Identification of the smaller species, and most non-game fish, is a problem for the expert with proper optical and other equipment, library facilities, and comparative collections.

Common names used in the accounts and lists are from Bailey et al. (1970).

The committee was aided by the experience and advice of several other ichthyologists who participated fully in the workshop discussions, and whose knowledge of North Carolina fishes and watershed conditions made their contributions invaluable. We acknowledge with thanks the very important inputs of the following: David A. Etnier, Wayne C. Starnes, and Noel Burkhead, Department of Zoology and Entomology, University of Tennessee, Knoxville; Royal D. Suttkus, Riverside Research Laboratories, Tulane University, New Orleans; Monte Seehorn, Fisheries Section, Southeast National Forests, USDA Forest Service, Atlanta; James D. Williams, Office of Endangered Species and International Activities, USFWS, Washington, DC; Richard D. Lindsey, Haywood Technical Institute, Clyde; Roger Schecter, Triangle J Council of Governments, Research Triangle Park; and E. David Frankenstein, Fishery Biologist, Army Corps of Engineers, Wilmington.

This entire report, including the Introduction, is a joint effort of the members of the Group Committee on Freshwater Fishes: Joseph R. Bailey, *Chairman*, Robert E. Jenkins, John G. Lundberg, Edward F. Menhinick, William M. Palmer, and Donald J. Tobaben.

The Watersheds and Critical Areas

Several examples of earlier environmental abuses, and their effects on local fish faunas in North Carolina, can be identified. They will serve to help evaluate other environmental changes which are now imminent or pending, and potential modifiers of our faunal resources.

As pointed out earlier, North Carolina is richly endowed with water resources, from its clear mountain streams and rivers, across a series of Piedmont systems at whose original hydrographic conditions we can only guess, to sluggish, dark coastal rivers and swamps and a variety of Coastal Plain lakes and ponds. Today only a few of our aquatic systems have not been abused beyond the necessary impact of land settlement, and these are under threats of major environmental change.

In this section we will review the present environmental conditions of the major watersheds and the status of their ichthyofaunas. The two main forms of environmental modification are impoundment of river channels to create lakes, and pollution in its many manifestations. Impoundment is essentially permanent in nature, destroys the habitats it covers, isolates the aquatic communities of streams tributary to it, and creates a barrier to migratory fishes. Reservoirs usually come to support an introduced lacustrine fish fauna of different composition than its fluvial predecessor. Pollution takes many guises -- thermal by introduction of heated water, chemical by the addition of foreign substances in solution, and particulate by addition of foreign or abnormal quantities of natural materials. The effects of pollution may be regarded as reversible, at least in part, through removal of the source, flushing of the system, and subsequent recolonization from tributary communities. This may require years to reach stability, but indications of improvement are often evident in a short time.

On occasion impoundment and pollution combine their undesirable forces to create truly adverse conditions in which the reservoir becomes a sink for the pollutants, rendering it unfit for recreation, homesites, or even most industrial uses.

The New River is the only one of our mountain rivers still in a semblance of its original condition. There is a dearth of mineral resources in the area where it flows, hence mining and washing have had little effect, and no major industrial pollutants have been introduced. The fast flowing streams of the system, with numerous rapids and optimal oxygenation, have been able to cope with minor domestic sewage and agricultural enrichment. The native fauna of the New is in a stable condition at the moment. As is widely known, however, construction of a dam just beyond our borders in Virginia is planned, and would impound the main stream and its two forks in North Carolina. The many facets of the case have been argued at length elsewhere and will not be repeated here. It is appropriate, however, to point out here the nature of the fish fauna of this distinctive stream.

About 29 native species, and several introduced, are known from the North Carolina portion of the New basin. Of these, four are endemic to the upper New and four others are native to the state only in this watershed. One other species, the flathead catfish, is of rare occurrence here and in the large Tennessee tributaries. All but one of these fishes are inhabitants of large streams with fast currents, just the habitat which would be eliminated by damming. Two of the species, the Kanawha minnow

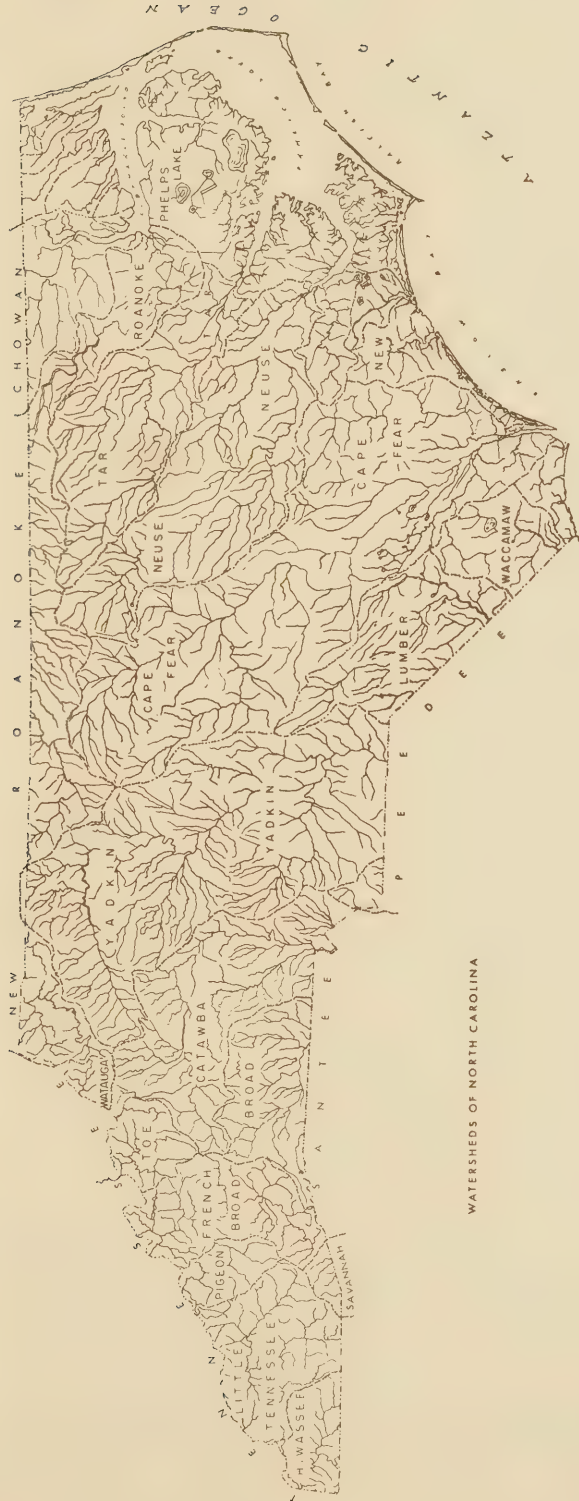


Figure 1. Watersheds of North Carolina.

and the Kanawha darter, are confined to the Blue Ridge portion of the stream and we feel they would stand little chance of surviving impoundment. The two other endemics and the five species peripheral in our state might survive somewhere in the basin, but most would be lost to North Carolina waters. Certainly the most optimistic outcome would be survival of a few small, scattered colonies which would have no chance of recruitment or genetic exchange with other such colonies. The New River is at once faunistically the most distinctive of our rivers and the one most gravely and immediately threatened.

The Watauga River in its North Carolina headwaters is a fast flowing and relatively unspoiled stream. It has been impounded in Tennessee as Watauga Lake, whose backwater just fails to reach our borders. The effect is formation of a barrier to upstream movement of fluviatile species. We have recorded 21 native species here, none of which is endemic or exclusive. A single rare species, the tangerine darter, is listed as of *Special Concern*. It is restricted to a deep riffle habitat.

The Nolichucky-Toe River has suffered more from the ravages of mining activity than any other native stream. Mica in the Spruce Pine area is separated by a washing process which returns its waste water into the river. This includes a milky colloidal suspension which is carried far downstream, settling as a film among the bottom interstices. This effectively suffocates any microorganisms and larger potential fish food items, such as insect larvae, molluscs, and worms, and buries fish eggs. With its food base eliminated, the fish fauna is virtually gone from the main channel. Thirty-six native species are known from this system. The sharphead darter is a large-water species believed *Extirpated* from the system. If it still occurs in one of the tributaries it must be considered *Endangered*. There is one recent record for the blotchside logperch, which is also considered *Endangered*. One other species, the olive darter, is *Threatened*. Four rare species, including two large catfishes, are characteristic of bigger streams and would certainly increase in abundance, as would all sport fishes, if productivity could be restored to the main stream by elimination of mine-washing and the flushing action that would occur in time.

Our largest member of the Tennessee system is the French Broad River, rising in Transylvania County, flowing past Asheville, and crossing the state border below Hot Springs. It also has the largest native fauna of the Tennessee tributaries, about 63 species, and the greatest number (8) of probably *Extirpated* species. One of these, the muskellunge, is being re-introduced from northern stock. Four additional species are considered *Endangered*, and six others *Threatened* or of *Special Concern*. Thus, over 20% of the native fauna is gone or in trouble. The species fall into two ecological groups: big river forms like the lake sturgeon, paddlefish, mooneye, and muskellunge; and small species inhabiting riffle areas, such as several darters, the spotfin chub, and the mountain madtom.

Although we cannot ascribe a definite cause to specific cases of extirpation or endangerment, there are at least four deleterious factors involved in this loss of diversity. Industrial pollution, from a cigarette paper plant at Brevard, a textile mill on Hominy Creek, and lesser sources in Rossman, Swannanoa, and Asheville, is probably the major culprit. Domestic waste disposal, gravel washing on the Swannanoa River, and general siltation from roads and agricultural lands, are other sources of pollution. Because nine species are known only from this system, and because it is potentially reclaimable as an excellent fishing stream, the

French Broad is considered a critical watershed. Without major pollution there is little doubt that fishing for sauger, muskellunge, rock bass, smallmouth bass, and spotted bass would add a significant dimension to the area's recreational resources.

The Pigeon River, a tributary of the French Broad which it joins below the state border, now consists of two segments. Above Canton it is a turbulent mountain stream of excellent water quality, containing a small fauna of about 18 native species. At Canton, the original biota has been virtually eliminated, probably by paper mill wastes. The highly acid, darkly stained waste water carries flocculent particles into Waterville Lake near the Tennessee border, which, as a result, is an unproductive and unused aquatic desert in a beautiful mountain setting. The original Pigeon River fauna was not sampled. The present fauna above Canton is that of a mountain tributary of the French Broad system without distinctive elements. One widely distributed but rare species, the tangerine darter, is marked for *Special Concern*.

The Little Tennessee River basin is the second largest system in North Carolina to drain into the Tennessee proper. In contrast to the French Broad it has narrower valleys and more rugged terrain, and the main stream is less dominant, with several tributaries of comparable size. There are several major impoundments in the system, Glenville Lake on the Tuckasegee River, Lake Aquone on the Nantahala, Lake Santeetlah on the Cheoah, and Lakes Emory and Fontana on the Little Tennessee. Pollution and siltation have been a lesser problem. The most serious industrial polluter, a textile mill at Sylva, was closed about a year ago for non-compliance with water quality regulations. Biologists from Western Carolina University report marked recovery already.

Approximately 40 native species have been recorded from the system, probably an incomplete figure since our knowledge of the fauna before the mid-1930's is scanty, especially for the larger river communities. Two species probably exterminated from the French Broad are known to persist here, the spotfin chub and the spotted darter. The olive darter and tangerine darter are of *Special Concern*. All are scarce riffle inhabitants requiring waters of good quality. The muskellunge may have been an original inhabitant, and is now being stocked from a northern strain.

The Hiwassee system is now largely a series of reservoirs. Lake Chatuge on the Georgia-North Carolina border, and Nottely Lake in Georgia, drain by their respective rivers into Hiwassee Reservoir. Farther, separated only by a dam, these waters drain into Appalachia Reservoir, ending at the Tennessee border. Again, we have very inadequate knowledge of the fauna of this watershed from pre-impoundment days. Of the 38 recorded native species, 10 are considered rare, of which the olive darter, tangerine darter, and river carpsucker are of *Special Concern*.

Savannah River headwaters cut into North Carolina in a series of deep, parallel gorges which drain south into the Atlantic from the Blue Ridge escarpment. The Chattooga, which has been designated a wild river, and the Whitewater, Thompson, Horsepasture, and Toxaway rivers, are the principal streams. Because of the precipitous nature of the terrain, only species preferring fast water are indigenous to the system. Thirteen such species have been recorded, and another one or two are known from a little below the border. Of these, four occur in the state only in this system and are of *Special Concern* — the rosyface chub, blue-head chub, turquoise darter, and redeye bass.

Several small reservoirs on the upper Horsepasture and Toxaway Rivers, built as resort and recreation areas, have had little influence on natural diversity of the ichthyofauna. A major power reservoir, Lake Keowee, which backs up water a short distance into North Carolina and effectively blocks fish migration from below, has recently been completed on the Whitewater-Thompson rivers. Fishes introduced into this new habitat are not likely to penetrate upstream. Aside from the effects of extensive timber exploitation there has been little adverse impact on these streams. In an area of minimal human occupancy they are viable candidates for preservation in their relatively pristine state.

The Broad River system, sharing a headwater divide with the French Broad, drains southeast to join the Congaree-Santee system in South Carolina. The headwaters of the Green and Broad Rivers are representative of the turbulent eastern slope mountain streams. The major lower tributaries, First and Second Broad rivers, typify warmer upper Piedmont area streams. Of the 30 or so native species listed, an undescribed chub and the seagreen darter are endemics of the upper Santee system and considered of *Special Concern*.

There are three hyaroelectric impoundments in this system, Lakes Summit and Adger on the Green River, and Lake Lure on the Broad. They do not fluctuate widely in level and support significant recreational fishing, almost entirely for introduced warm water species. Pollution from mining activities and sand removal operations is causing local degradation. In the Piedmont sections, runoff from rural roads and agricultural lands creates an inevitable but undesirable degree of turbidity.

The Catawba system, like the Yadkin to follow, has felt the hand of man most heavily. Except for the uppermost tributaries nothing remains in a semblance of natural condition. Seven major power projects impound 64,000 acres of successive lakes along the main channel, from Lake James at 360 meters (1,200 feet) elevation to Lake Wylie (=Catawba Lake) at 171 meters (570 feet) on the South Carolina line. In addition, widespread but not intensive pollution and runoff have modified the river habitats. Nearly 50 native species have been recorded here, 2 of which are shared with the Broad River as endemics of the upper Santee and are listed above as of *Special Concern*. The Carolina darter, a very rare but scattered species represented by several records from the Catawba, should be added to this group.

Of special note in this system is the presence of some 15 species from the upper Catawba which are characteristic of the fauna of western slope rivers. Some, like the largemouth bass above Linville Falls, are obviously introductions. Others may be releases from bait pails, or may be the result of stream capture of Nolichucky headwaters at some remote time in the past. Three specimens of the highfin carpsucker from Lake Norman are probably from introduced stock, but there is a possibility that they and a Cape Fear specimen represent an undescribed form. The status of this fish should be considered "undetermined" for the present.

The Yadkin River is second only to the Cape Fear system in area drained, with 7,180 square miles. For about a third of its length it flows northeasterly, draining the eastern slopes of our northern Blue Ridge, then turns abruptly in a southeastern direction as a major Piedmont river, receiving tributaries from both sides. The W. Kerr Scott Reservoir is located in the upper mountain section for flood control.

The small Salem and Winston lakes were designed as water supplies for Winston-Salem. The High Rock, Tuckertown, Badin, Tillery, and Blawie Falls reservoirs serve hydroelectric plants. Thus, the main stream, like the Catawba, links a series of man-made lakes and supports an equally unnatural fauna. The Yadkin is tributary to the Pee Dee in South Carolina. Fifty-two recorded species are considered native to the Yadkin, but none is endemic or of particular concern. One brook species, the redbelly darter, is shared with the adjacent Roanoke-Dan system as a native.

The Sand Hills of our southern upper Coastal Plain give rise to one of our most distinctive streams, the Lumber River, which drains into the Little Pee Dee River in South Carolina. It lies entirely within the Coastal Plain and, besides a portion of the Sand Hills, drains extensive swamplands which give it the dark stain and low pH of such waters. Thirty-seven native species are now known, including three or four still undescribed, two of which are also known from the adjacent Cape Fear system. Two of the new species are minnows and the third a madtom catfish. The pinewoods darter is endemic to the system, and two other fish are peripheral from the south, one a distinctive southern race of the swamp darter and the other the taillight shiner, shared with the adjacent Waccamaw system. The tiny pygmy sunfishes are represented by two and perhaps a third (undescribed?) species, but this group needs critical review before our conclusions are firm. Thus, nearly 20% of the native fauna of this small system is of unusual interest because of limited distribution.

Pollution is present in the Lumber, most of it emanating from municipalities and some industrial sources. While not in critical loads, improvement is urgently hoped for. Greater immediate threats to the fish fauna are the several plans under consideration to channelize and drain certain areas for "flood control".

The Waccamaw system is virtually continuous with the aforementioned Lumber through the common swamplands they drain. They also share most of their faunal elements, but the existence of Lake Waccamaw sets this system apart as a distinctive unit. The large lake habitat has apparently served as a minor center of evolutionary differentiation, and as a refuge for earlier forms. Consequently, two species are found only here, the Waccamaw silverside and the Waccamaw darter. A third species, the Waccamaw killifish, now appears to also occur in Phelps Lake. All three show the elongation which often characterizes lake species as compared with stream relatives. Although all are doing well at the moment, they are placed in the *Endangered* category because of the delicate trophic balance of the lake. Its immediate borders support a large and growing seasonal resident and tourist population, without benefit of a modern waste disposal system. The lake is shallow and incapable of assimilating a heavy load of added nutrients, either domestic wastes or fertilizer runoff from yards or other sources. Algal blooms and increased growth of higher aquatic plants would lead to rapid eutrophication, which would not only endanger the native fauna but would render the lake less attractive for its present role as a recreational site. The construction of drainage canals to provide additional real estate on the eastern side of the lake is further compounding the problem.

Our largest watershed is the Cape Fear, entirely contained within the state, which drains an area of 9,150 square miles. Its headwaters rise in the central Piedmont and flow southeastward into an extensive

Atlantic estuary below Wilmington. The Cape Fear River is formed on the lower Piedmont by confluence of the Deep and Haw rivers. Both have major tributaries, the Rocky River of the former, and the New Hope River of the latter. On the Coastal Plain, the South and Northeast Cape Fear are major tributaries. A number of small "bay lakes" on the Coastal Plain, most of them in Bladen County, add variety to the hydrographic profile of the watershed. They add little to faunal diversity, however, since most are dark water lakes of very low productivity.

In keeping with its size the Cape Fear ranks second (to the Neuse) in diversity among our watersheds, with 78 species of fishes. On the other hand, lack of distinctive habitats or long standing isolation has limited evolution of endemic forms to a single species, the Cape Fear shiner. It occupies a restricted range just above the fall line where the river begins. A portion of the population of this minnow could be imperiled by damming and potential impoundment. Two undescribed fishes, a chub and a madtom, are Coastal Plain species shared with the Lumber system and are of *Special Concern*. To this category we add the Carolina darter, which, though rather widespread, is everywhere rare. A single highfin carpsucker is known from the Cape Fear River and, as Dr. Jenkins surmises, may represent an undescribed form. If this is the case its rarity would qualify it for the *Threatened* category.

Draining a large portion of the populous central Piedmont, the Cape Fear system carries its share of municipal, industrial, and agricultural pollution. The Haw River, with industrial wastes, and the New Hope River, with municipal wastes, are so heavily polluted that filling behind the B. Everett Jordan Dam has been delayed for fear of creating an intolerable waste sink. This is the only major dam in the system, but there are five low dams on the main stream, the lowest three provided with boat locks. These have no significant effect on fish diversity, but do impede natural upstream movement. Improvement of water quality would enhance the recreational values of the watershed.

The Northeast Cape Fear River is the last major tributary joining the main stream at the head of its estuary at Wilmington. It drains a large section of swampland in Pender, Duplin, and neighboring counties. Aside from some local industrial pollution it is free from major problems. Its fish fauna has no distinctive elements.

The Neuse River basin has the richest recorded fish fauna of our watersheds, though it is only third in drainage area. Some 80 native species are known, of which 1, perhaps 2, have been extirpated in recent times. The shortnose sturgeon formerly ascended the Neuse and other northeastern rivers for spawning, but has not been found in fresh waters of our state for many years.† It is on the official federal and IUCN lists of endangered species. The Atlantic sturgeon, always more common than the shortnose, is rapidly approaching a similar status and, at least in North Carolina, is in danger. Both sturgeons are discussed in the report on Marine Fishes in this publication. A minnow, the bridle shiner, was taken in 1970 in Craven County, the only state record of a species found from Virginia northward. Such distributional patterns are of great importance to the understanding of climatic and environmental history. The Craven County record probably represents a relict population which has been endangered or extirpated by channelization since its discovery. One endemic species, the Carolina madtom, is shared with the Tar system. It is an inhabitant of larger streams of the upper Coastal Plain. As a distinctive

element of the Neuse-Tar fauna, it is of *Special Concern*. The Roanoke bass, a local game species also known from the Roanoke and Chowan systems, falls in this category. The widespread but rare Carolina darter, which occurs sporadically in small colonies over the lower Piedmont, and the scarce least brook lamprey, which reaches its southern limit here, are also in this category.

The Neuse River is formed by the confluence of the Eno and Flat rivers in the lower Piedmont northeast of Durham. It flows southeastward to a large estuary at New Bern and empties into Pamlico Sound. Lake Michie on the Flat River serves Durham as a water supply. Three low dams of the overflow type near Wake Forest, Raleigh, and Goldsboro, impede fish movement except at very high water levels. An impoundment, Falls Lake, has been proposed for the river between Raleigh and Wake Forest, to serve flood control and water supply purposes. The dam, virtually on the fall line, would back up water above the Eno-Flat confluence. The Carolina madtom, and the migratory redhorses of the genus *Moxostoma*, are the species most likely to be affected adversely by such an impoundment. Since the streams of this basin head in and pass through some of the most populous areas of the state, pollution is a major problem in maintaining their natural fish diversity.

The Tar River parallels the Neuse to the northeast, emptying at Washington into the Pamlico River estuary of Pamlico Sound. Faunistically it could be a tributary of the Neuse, which it must have been during the late Pleistocene, about 18,000 years ago. All of its fish species, except the White sucker, are also in the Neuse. It is a smaller and less well known stream, however, and some Neuse species are apparently lacking. Two aquatic vertebrates are endemic in both systems — the Carolina madtom, which is accorded the status of *Special Concern*, and a salamander, the Neuse River Waterdog, discussed in the section on *Amphibians and Reptiles*. The Roanoke bass is a subject of *Special Concern* in the Tar system. The river lacks major impoundments and has been spared severe industrial pollution. Since it drains largely agricultural land, however, soil erosion and turbidity are a problem. Stream channelization, a traumatic practice for local fish faunas, is a continuing threat in the lower section of this and other lowland watersheds.

The fresh waters of the peninsula between Albemarle and Pamlico Sounds are made up of a few sizeable lakes, the Scuppernong and Alligator rivers, and several smaller streams and swamps. With one outstanding exception neither they nor their typical Coastal Plain-estuarine fauna are imperiled. The problem area is Phelps Lake, the north shore of which is occupied by Pettigrew State Park. A generation ago the area between the Park and the Intercoastal Waterway to the south, which connects the Pungo and Alligator Rivers, was a vast wooded swamp. Today most of this has been cleared, ditched, and put into cultivation as First Colony Farms. Much of the immediate shore line of Phelps Lake has been developed for vacation homes. These cultural changes have wrought very basic modifications in the environment, affecting natural vegetation, drainage and water-levels, soils, and other components, as well as land use. A detailed report on the hydrology of the entire region was recently published (Heath, 1975).

In 1964, the north shore of Phelps Lake had a firm sand bottom, with a light covering of shifting loose silt of peat origin which did not

seriously impede seining efforts. In 1965 Crowell (1966) found that "The lake bottom is composed primarily of hard-pan sand, but in certain areas fibrous and pulpy peat lay on top of the sand. These areas of peat shift with the wave action and at the time of the 1965 survey, the quantity of peat transported to the northern shore by wave action had extended the shore line in places by as much as 100 feet into the lake." In 1972 I found that the lake had changed considerably since 1964. Water level was up 30 cm or more and the predominantly sand bottom was now covered along the north shore with 15 to 60 cm or more of fine silt and muck. Sand beaches, formerly extensive on the west and south shores, were gone, and the water was more deeply stained, approaching the color of Waccamaw water. In May, 1975, the lake shore off Pettigrew State Park was very silty and the dock area knee to waist deep in muck. These details are reported because the record is at hand, illustrating the speed with which natural waters of this type respond to man's intervention. With the clearing, draining, and cultivation of thousands of acres adjacent to the lake, the light peat soil has apparently been periodically wind-carried into the water. Here prevailing wind and wave action has taken it to depths of a meter and more along the north shore. Not only is the recreational function of the State Park seriously impaired, but the resort property and the entire lake fauna are endangered. We are not optimistic about the future of Phelps Lake. Reversal of deterioration seems unlikely, and staying the process would demand a redirection of development plans. Making pastures of the closest lands would be the best immediate solution.

At least 26 species of fishes are recorded from Phelps Lake. One of these is the *Endangered* Waccamaw killifish, previously thought to occur only in Lake Waccamaw. It probably illustrates a relict distributional pattern dating from some thousands of years ago rather than a single-lake endemic. Other fishes seem not to be unusual, but three are known from only one or two specimens or juveniles; these species may prove interesting with better samples.

The Roanoke River rises in and drains most of its watershed in Virginia before crossing the state border to empty into Albemarle Sound. A main tributary, the Dan River, makes a sizeable incursion into our northern upper Piedmont before joining the main river at the head of Buggs Island Reservoir, Virginia. The Roanoke has the largest native fish fauna of any river on the east coast of North America. Our records show about 70 species from the North Carolina portions of the watershed. Five of these are found in the state only in the Dan River. The cutlips minnow, Roanoke hog sucker, bigeye jumprock, Roanoke bass, and riverweed darter, are of *Special Concern*, and the orangefin madtom is *Threatened*. Consideration is being given to yet another dam on the Dan River in Virginia, which could spell the demise of the madtom. The others, of more headwater distribution, are given a better chance for survival.

The Roanoke system is marked by power reservoirs, one of which, Lake Hyco, is confined to North Carolina. Buggs Island Lake, Lake Gaston, and Roanoke Rapids Lake, separated from each other only by successive dams, form a continuous impoundment along the Virginia-North Carolina border. This chain supports one of the few land-locked populations of striped bass in the world. Below these lakes the Roanoke is also justly famous for its striped bass runs; the fish congregate at Weldon to spawn. Severe industrial pollution just above this point at Roanoke Rapids imperils

successful spawning, and only by costly management through salvaging ripe eggs and milt for hatchery treatment does the run survive. The local water will not support the fish's early developmental stages.

The river systems lying to the east and north of the Roanoke basin include the Chowan and its tributaries, and the lesser Perquimans, Pasquotank, and North Rivers. These may be treated together since they are all dark water streams of similar character and fauna, typical of the Coastal Plain. Although they support locally important sport and commercial fisheries, they have no faunal features of unique interest and none of the fish species are in a precarious state. These rivers are certainly worthy of the best management efforts, but do not figure as sites of endangered species.

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Editor's Note: On September 11, 1976, President Gerald Ford signed a bill amending the Wild and Scenic Rivers Act (PL 94-407) to include 26.5 miles of the New River, from Dog Creek to the Virginia line. This segment of the river is now protected from change by a proposed dam in Virginia.

Freshwater Fishes -- Species List

Species List

Key to Status (column headed S):

E = *Endangered*
T = *Threatened*

SC = *Special Concern*
Ex = *Extirpated*

Key to Watersheds (column headed W):

Bro = Broad, tributary to
Congaree-Santee
Cat = Catawba, tributary to
Congaree-Santee
CFe = Cape Fear
Coa = two or more major
coastal rivers
FBr = French Broad, tributary
to Tennessee
Hiw = Hiwassee, tributary to
Tennessee
LTe = Little Tennessee, trib-
utary to Tennessee
Lum = Lumber, tributary to
Little Pee Dee

LWa = Lake Waccamaw
Nes = Neuse
New = New, tributary to
Kanawha
PhL = Phelps Lake
Pig = Pigeon, tributary to
Tennessee
RoD = Roanoke-Dan
Sav = Savannah, headwaters
Tar = Tar
Toe = Nolichucky-Toe, trib-
utary to Tennessee
Wat = Watauga, tributary
to Tennessee
Yad = Yadkin, tributary
to Pee Dee

Species	S	W
Agnatha		
Petromyzontidae		
<i>Lampetra aepyptera</i> , Least brook lamprey	SC	Tar, Nes
Osteichthyes		
Acipenseridae		
<i>?Acipenser fulvescens</i> , Lake sturgeon 280	Ex?	FBr
<i>Acipenser oxyrhynchus</i> , Atlantic sturgeon	SC	Coa
Polyodontidae		
<i>Polyodon spathula</i> , Paddlefish 288	E	FBr
Hiodontidae		
<i>Hiodon tergisus</i> , Mooneye 289	E	FBr
Esocidae		
<i>Esox masquinongy</i> , Muskellunge 282	Ex?	FBr
Cyprinidae		
<i>Exoglossum laurae</i> , Tonguetied minnow	SC	New
<i>Exoglossum maxilllingua</i> , Cutlips minnow	SC	RoD
<i>Hybopsis monacha</i> , Spotfin chub 290	Ex?	FBr
	E	LTe

Freshwater Fishes -- Species List

<i>Hybopsis rubrifrons</i> , Rosyface chub	SC	Sav
<i>Hybopsis</i> new species I	SC	Bro, Cat
<i>Hybopsis</i> new species II	SC	Lum, CFe
<i>Nocomis leptocephalus interocularis</i> , Bluehead chub	SC	Sav
<i>Nocomis platyrhynchus</i> , Bigmouth chub	SC	New
<i>Notropis bifrenatus</i> , Bridle shiner 286	E, Ex?	Nes
<i>Notropis mekistocholas</i> , Cape Fear shiner	SC	CFe
<i>Notropis rubellus</i> , Rosyface shiner	SC	New
<i>Notropis scabriceps</i> , New River shiner	SC	New
<i>Phenacobius teretellus</i> , Kanawha minnow 294	T	New
<i>Pimephales notatus</i> , Bluenose minnow	SC	New
<i>Semotilus</i> new species	SC	Lum
Catostomidae		
<i>Carpiodes carpio</i> , River carpsucker	SC	FBr, Hiw
<i>Hyentilium roanokense</i> , Roanoke hog sucker	SC	RoD
<i>Moxostoma ariommum</i> , Bigeye jumprock	SC	RoD
Ictaluridae		
<i>Noturus eleutherus</i> , Mountain madtom 283	Ex	FBr
<i>Noturus furiosus</i> , Carolina madtom	SC	Nes, Tar
<i>Noturus gilberti</i> , Orange-fin madtom 294	T	RoD
<i>Noturus</i> new species	SC	Lum, CFe
Cyprinodontidae		
<i>Fundulus waccamensis</i> , Waccamaw killifish 291	E	LWa, PhL
Atherinidae		
<i>Menidia extensa</i> , Waccamaw silverside 292	E	LWa
Centrarchidae		
<i>Ambloplites cavifrons</i> , Roanoke bass	SC	Tar, Nes, RoD
<i>Micropterus coosae</i> , Redeye bass	SC	Sav
<i>Micropterus punctulatus</i> , Spotted bass	SC	FBr, Hiw
Percidae		
<i>Etheostoma acuticeps</i> , Sharphead darter 284	Ex	Toe
<i>Etheostoma collis</i> , Carolina darter	SC	Cat, CFe, Nes
<i>Etheostoma inscriptum</i> , Turquoise darter	SC	Sav
<i>Etheostoma jessiae</i> , Blueside darter 292	E	FBr
<i>Etheostoma kanawhae</i> , Kanawha darter 295	T	New

Freshwater Fishes -- Species List and Accounts

<i>Etheostoma maculatum</i> , Spotted darter	288	Ex	FBr
		SC	LTe
<i>Etheostoma mariae</i> , Pinewoods darter		SC	Lum
<i>Etheostoma perlongum</i> , Waccamaw darter	293	E	LWa
<i>Etheostoma podostemone</i> , Riverweed darter		SC	RoD
<i>Etheostoma simoterum</i> , Tennessee snub-nose darter	286	Ex	FBr
<i>Etheostoma thalassimum</i> , Seagreen darter		SC	Bro,
			Cat
<i>Percina aurantiaca</i> , Tangerine darter		SC	Wat,
			FBr,
			Pig,
			LTe
<i>Percina burtoni</i> , Blotchside logperch	288	E or Ex	FBr
		E	Toe
<i>Percina caprodes</i> , Logperch	296	T	FBr
<i>Percina macrocephala</i> , Longhead darter	287	E or Ex	FBr
<i>Percina maculata</i> , Blackside darter		SC	New
<i>Percina oxyrhyncha</i> , Sharpnose darter		SC	New
<i>Percina sciera</i> , Dusky darter		SC	FBr
<i>Percina squamata</i> , Olive darter	296	T	Toe
		SC	FBr,
			Hiw,
			LTe

SPECIES ACCOUNTS

PISCES; ACIPENSERIFORMES; ACIPENSERIDAE (Sturgeons)

?*Acipenser fulvescens* Rafinesque

LAKE STURGEON

Description: A large fish, 1 to 1.5 m (3 to 5 ft.) long, with ventral mouth, barbels on the lower surface of the snout, and five rows of bony tubercles on the body (one dorsal, two lateral, and two ventro-lateral). The tail is heterocercal, with the upper lobe longer than the lower. See Hubbs and Lagler (1947, Plate opp. p. 32) for a color illustration.

Distribution: Range -- central and SE Canada, Great Lakes, midwest U. S., south in Mississippi basin to Tennessee River.

North Carolina -- questionable in French Broad.

Habitat and Mode of Life: The lake sturgeon is an inhabitant of fresh and occasionally brackish waters, usually shoals of lakes and large rivers. They live on the bottom, often at considerable depths, and feed on bottom-dwelling organisms like mollusks, insects, crayfish, fish eggs, and some plants.

Reproduction: Spawning occurs in late spring and early summer, usually in swift waters. The adhesive eggs are dropped on the bottom amongst stones and debris.

Status: *Extirpated?* On 8 October 1945 eight sturgeons weighing up to 6.8 kg (15 lb.) and up to nearly 1 m (3 ft.) in length were taken in the French Broad River near Hot Springs by a Mr. West. They were not preserved, and sturgeons have not been recorded since. The fish were probably the lake sturgeon, but may have been the shovelnosed sturgeon, *Scaphirhynchus platyrhynchus*, which occurs in the Mississippi system to northern Alabama. The latter species differs in having the caudal peduncle completely armored, a filament on the upper lobe of the caudal fin, and no spiracle (a small opening at the upper edge of the gill cover) present. We can only view whatever the species was, most likely the lake sturgeon, as probably *Extirpated* from our rivers. If by chance it persists regularly or occasionally, however, it should be given all possible protection and considered *Endangered*.

Remarks: Most sturgeons are migratory fishes, moving from the sea into fresh waters, or for considerable distances in fresh water systems, to spawn. The lake sturgeon was reported by Trautman (1957) to have been migratory from Lake Erie up its tributary rivers, and from larger to smaller rivers in Ohio, in earlier times when it was common. He considered dams preventing the spawning runs to be one of the important causes of its great decline. The Hot Springs specimens may have been immature fish migrating downstream to larger waters, since in the Great Lakes region lake sturgeons do not attain maturity until 1 to 1.2 m (3 to 4 ft.) in length and about 22 years of age (Harkness 1924; Schneberger and Woodbury 1944). In view of this retarded reproductive pattern, sturgeons everywhere need our utmost efforts to maintain them.

- References: Brimley, C. S. 1946. The freshwater fishes of North Carolina. Installments 1 and 2. Carolina Tips 9(3):10-11 and 9(4): 14-15.
- Harkness, W. J. K. 1924. The rate of growth and the food of the lake sturgeon (*Acipenser rubicundus* LeSueur). Univ. Toronto Studies, Biol. Ser. No. 24, Pub. Ont. Fish. Res. Lab., No. 18:13-42.
- Hubbs, C. L., and K. F. Lagler. 1947. Fishes of the Great Lakes Region. Cranbrook Inst. Sci., Bull. 26. Bloomfield Hills, MI. 186 pages.
- Schneberger, E., and L. A. Woodbury. 1944. The lake sturgeon, *Acipenser fulvescens* Rafinesque, in Lake Winnebago, Wisconsin. Trans. Wisc. Acad. Sci. Arts Letters 36:131-140.
- Trautman, M. B. 1957. The Fishes of Ohio. Ohio State Univ. Press, Columbus, OH. 683 pages.

PISCES; SALMONIFORMES; ESOCIDAE
(Pikes)

Esox masquinongy Mitchill

MUSKELLUNGE

Description: A large, elongate fish with the dorsal and anal fins far back on the body. The maximum size attained once exceeded 1.8 m (6 ft.) and 45 kg (100 lb.), but most adults seen today range in length from 70 to 120 cm (27 to 47 in.) and 2 to 16 kg (5 to 35 lb.) in weight. The head is long and pointed, and the large mouth has prominent, needle-like teeth. The cheeks and opercles (gill covers) are without scales on the lower half. General body color is variable but most always light, greenish or brownish, with dark markings, usually vertical bars. For illustrations see Hubbs and Lagler (1947, Figures 187, 188).

Distribution: Range — from north of the Great Lakes and the St. Lawrence basins, south through the Ohio and Tennessee systems.

North Carolina — French Broad and Little Tennessee rivers.

Habitat and Mode of Life: The muskellunge is a fish of large rivers and lakes, and is usually not found far from heavy vegetation. They are voracious predators; adults feed mostly on other fish, but will take almost anything that moves in the water, including waterfowl. Larger fish apparently require large prey, and will refuse smaller items even if present in abundance.

Reproduction: Spawning occurs in the spring, usually in shallow water with dense plant life. The eggs are non-adhesive and are scattered in vegetation.

Status: Probably *Extirpated* as a native species. The muskellunge apparently occurred naturally in the French Broad and Little Tennessee rivers, but whether or not it survives from the original population is unknown. The species is becoming scarce over its entire range. Both North Carolina rivers are now being stocked with small specimens of the same "subspecies," but from northern populations. The "tiger," a hybrid between the muskellunge and the northern pike, *Esox lucius*, is being stocked in the Hiwassee system and Lake Adger.

Reference: Menhinick, Burton and Bailey (1974); see list following introduction.

PISCES; SILURIFORMES; ICTALURIDAE
(Freshwater Catfishes)

Noturus eleutherus Jordan

MOUNTAIN MADTOM

Description: A small, blotched, madtom catfish attaining a total maximum length of about 7.5 cm (3 in.). The body is short and stocky with a rounded caudal fin, and the adipose fin (a fatty dorsal fin in front of the tail) is nearly free posteriorly. See Hubbs and Lagler (1947, Figure 180), and Taylor (1969, Plate 14) for photographs.

Distribution: Range -- Ohio, Cumberland, and Tennessee River systems, and Ouachita and Red rivers of the Ozark region.

North Carolina -- French Broad River.

Habitat and Mode of Life: According to Taylor (1969) this species "is chiefly a resident of large or fairly large, moderate or swift-flowing streams or rivers. It has been taken principally in streams containing moderate or large stones, rubble, gravel, and sand, and usually lives in clear water." Madtoms are nocturnal animals and may be missed by ordinary day collecting.

Reproduction: Spawning probably occurs at night in early spring, extending into the fall. A nest is made in a cavity, gravel, or under some object, and the male probably guards the eggs and early young.

Status: Presumed *Extirpated*. There is a single record for Spring Creek, French Broad River, near Hot Springs (Jordan 1890), supported by material in the U. S. National Museum of Natural History which was studied by Taylor (1969).

References: Hubbs, C. L., and K. F. Lagler. 1947. Fishes of the Great Lakes Region. Cranbrook Inst. Sci. Bull. 26, Bloomfield Hills, MI. 186 pages.

Jordan, D. S. 1890. Report of explorations made during the summer and autumn of 1888 in the Allegheny region of Virginia, North Carolina and Tennessee, and in western Indiana, with an account of the fishes found in each of the river basins of those regions. Bull. U. S. Fish Comm. 8:97-173.

Taylor, W. R. 1969. A revision of the catfish genus *Noturus* Rafinesque with an analysis of higher groups in the Ictaluridae. U. S. Nat. Mus. Bull. 282, Washington, DC. 315 pages.

PISCES; PERCIFORMES; PERCIDAE
(Perches)

Etheostoma acuticeps Bailey

SHARPHEAD DARTER

Description: A stout, sharp-headed darter with dorsal and ventral outlines equally curved, attaining a total length of around 7.5 cm (3 in.). The male is dark olive, with about 14 obscure, dark vertical bands. The fins are blue green to greenish white at the margins, and the first dorsal has an anterior dark blotch. The breast is dull blue green, the underside greenish white. Females are lighter with olive fins, and lack the blue green colors. See Bailey (1959) for complete description.

Distribution: Range -- Tennessee River system, North Carolina, Tennessee, Virginia.

North Carolina -- North Toe River, Mitchell Co.

Habitat and Mode of Life: At the type locality, the South Fork of the Holston River, it was found at low water stage to be "apparently confined to the deeper, faster riffles near the center of the stream." (Bailey 1959). It probably also occurs in rather shallow water. The species feeds on bottom-dwelling invertebrates, especially insect larvae (Jenkins and Burkhead 1975).

Status: *Extirpated*. The South Holston River, Tennessee, type-locality is now under 57 m (190 ft.) of water in the South Holston Reservoir. Specimens collected in the North Toe River above Spruce Pine, Mitchell County, North Carolina, in 1930, now in the collections of the Academy of Natural Sciences of Philadelphia, were identified as this species by Knapp and Collette (Zorach 1972). It has not been seen here since. More recently it was found in the South Fork Holston, Washington County, Virginia (Jenkins and Burkhead 1975), and the lower Nolichucky River, Tennessee (Saylor and Etnier 1976). These authors see excessive siltation in the upper Nolichucky from mining activities in North Carolina as responsible for its elimination in that area. Although presumed *Extirpated*, it may still persist in favorable habitats of the state. These habitats are difficult to sample efficiently. The presence of a downstream population also leaves open the possibility that it might re-enter the upper Nolichucky if favorable conditions can be returned. This fish was considered *Endangered* at the Workshop on Threatened and Endangered Vertebrates of the Southeast, but Saylor and Etnier (1976) have suggested its status be changed to *Threatened*.

References: Bailey, R. M. 1959. *Etheostoma acuticeps*, a new darter from the Tennessee River system, with remarks on the subgenus *Nothonotus*. Occas. Pap. Mus. Zool. Univ. Mich. 603:1-10.
Jenkins, R. E., and N. M. Burkhead. 1975. Recent capture and analysis of the sharphead darter, *Etheostoma acuticeps*, an endangered percoid fish of the Upper Tennessee River drainage. Copeia No. 4:731-740.

- Saylor, C. F., and D. A. Etnier. 1976. Rediscovery of the sharphead darter, *Etheostoma acuticeps* Bailey, in the Lower Nolichucky River, Tennessee. ASB Bull. 23(2):93. Abstract.
- Zorach, T. 1972. Systematics of the percoid fishes *Etheostoma camurum* and *E. chlorobranchium*, new species, with a discussion of the subgenus *Nothonotus*. Copeia No. 3:427-447.

Etheostoma maculatum Kirtland

SPOTTED DARTER

Description: A darter reaching a length of 6.4 cm (2 1/2 in.), without dorsal saddles but with longitudinal stripes on the sides. Males have many irregularly placed red spots, and white-margined, cloudy fins. Females have some scattered darker spots and barred fins. See Eddy (1957, p. 218) for a line drawing, and Zorach and Raney (1967, p. 302) for a photograph.

Distribution: Range -- Ohio and Tennessee River systems.
North Carolina -- Little Tennessee and French Broad systems.

Habitat and Mode of Life: Riffles over gravel and rubble bottom, in very fast currents of good sized streams and rivers, are the preferred habitat of this darter. Its food consists of insect larvae and water mites (Raney and Lachner 1939).

Status: Probably *Extirpated* from the French Broad system, but still extant in the Cullasaja and Oconoluftee rivers of the Little Tennessee system, where it rates a status of *Special Concern*. What proved to be the southeastern subspecies of the spotted darter was described by Cope (1870) from Warm Springs Creek, Madison County, as *Poecilichthys vulneratus*. The specimen is still in good condition, but repeated search for the species at the type locality has been in vain. Several nominal records for this fish in North Carolina and elsewhere have proved to be based on *Etheostoma chlorobranchium*, under the name *Etheostoma* (or *Poecilichthys*) *camurum* (Zorach 1972; Zorach and Raney 1967).

- References: Eddy (1957); see list following introduction.
- Cope, E. D. 1870. A partial synopsis of the fishes of the fresh waters of North Carolina. Proc. Amer. Philosoph. Soc. 11:448-495.
- Raney, E. C., and E. A. Lachner. 1939. Observations on the life history of the spotted darter, *Poecilichthys maculatus* (Kirtland). Copeia No. 3:157-165.
- Zorach, T. 1972. Systematics of the percoid fishes *Etheostoma camurum* and *E. chlorobranchium*, new species, with a discussion of the subgenus *Nothonotus*. Copeia No. 3:427-447.
- _____, and E. C. Raney. 1967. Systematics of the percoid fish, *Etheostoma maculatum* Kirtland, and related species of the subgenus *Nothonotus*. Amer. Midl. Natur. 77(2):296-322.

Description: A small darter of about 7.5 cm (3 in.) in length, with a very blunt, rounded snout. The fins of males are very large, greenish above and yellowish to orange below, with about 10 dark green, squarish blotches on the side which are more-or-less connected. Some small red and yellow spotting may be present dorsally. Females and young are less colorful. See Smith (1907, p. 259) and Eddy (1957, p. 209) for line drawings.

Distribution: Range -- upper Tennessee River system from Alabama to Virginia.

North Carolina -- French Broad River.

Habitat and Mode of Life: Like most darters, this species prefers riffle areas over hard bottoms. It probably feeds on bottom-dwelling invertebrates.

Status: *Extirpated*. Cope (1870) included this species in a list of fishes from the French Broad, and a single specimen which he collected is in the U. S. National Museum of Natural History collections. No recent information on this fish in North Carolina exists, and it is presumed gone from the state. It is still extant in eastern Tennessee.

References: Eddy (1957), Smith (1907); see list following introduction.

Cope, E. D. 1870. A partial synopsis of the fishes of the fresh waters of North Carolina. Proc. Amer. Philosoph. Soc. 11:448-495.

PISCES; CYPRINIFORMES; CYPRINIDAE
(Minnows and Carps)

Notropis bifrenatus (Cope)

BRIDLE SHINER

Description: A small, yellowish minnow not exceeding 6.4 cm (2 1/2 in.) in length. There is a black stripe on each side, from the nostril to the base of the tail. See Eddy (1957, p. 122) for a line drawing.

Distribution: Range -- Atlantic coast, Maine to Virginia (Rappahannock, York, and Chowan Rivers).

North Carolina -- Tucker Creek, lower Neuse basin, Craven Co.

Habitat and Mode of Life: This is a fish of ponds and warm water streams. Here it occurs in shallow or slow currents, over muddy or silty bottom usually provided with moderate to abundant aquatic vegetation.

Status: *Endangered*, possibly *Extirpated*. The Tucker Creek locality is evidence of the existence of a possibly disjunct population well to the south of its normal range. The site has been subjected to environmental modification since the discovery of this shiner, which may have eliminated the population. Other populations may exist between Tucker Creek and the nearest Virginia localities, but if so the bridles shiner must be an exceedingly rare species.

Remarks: Probably the greatest value of the discovery of the Tucker Creek population is in the clues it offers to the past history of our fish fauna.

References: Eddy (1957); see list following introduction.
Jenkins, R. E., and T. Zorach. 1970. Zoogeography and characters of the American cyprinid fish, *Notropis bifrenatus*. Chesapeake Sci. 11(3): 174-182.

PISCES; PERCIFORMES; PERCIDAE
(Perches)

Percina macrocephala (Cope)

LONGHEAD DARTER

Description: A slender darter about 10 cm (4 in.) total length. Adult males are olive yellow, with about 12 squarish median saddles. These are bordered laterally by dark vermiculations on the upper back, and below them a light yellow streak separates a lateral series of about 10 confluent dark spots along the lateral line. The venter is yellowish white. Females and young are similar, but the colors are muted. See Eddy (1957, p. 204) for a line drawing.

Distribution: Range -- upper Ohio, Cumberland, and Tennessee River systems.

North Carolina -- French Broad River.

Habitat and Mode of Life: Trautman (1957) reports that "The long-head darter inhabits the deeper riffles and pools with current, of the mountain-torrent type of moderate or large-sized Appalachian streams which normally have fairly clear waters and clean bottoms of gravel and boulders". Menhinick et al. (1974) say that it "Inhabits slack water areas of larger streams (Etnier, pers. comm.)".

Status: *Endangered*, probably *Extirpated*. This species is admitted to our state list on the basis of material in the Cornell University collection taken in the French Broad River near Skyland over 35 years ago. It has not been retaken in spite of considerable collecting effort, and may be gone from the state.

References: Eddy (1957), Menhinick et al. (1974); see list following introduction.

Trautman, M. B. 1957. The Fishes of Ohio. Ohio State Univ. Press, Columbus, OH. 683 pages.

Percina burtoni Fowler

BLOTCHSIDE LOGPERCH

Description: A large, yellowish darter, about 17.5 cm (7 in.) total length, with an inferior mouth and a fleshy, protuberant snout. The sides have about 10 horizontal oblong blotches. The scales are very small, and number about 85-90 along the lateral line.

Distribution: North Carolina endemic. Early records from Swannanoa River tributary to French Broad, and a recent specimen from South Toe River, refer to this form.

Habitat and Mode of Life: A species of small rivers or large creeks, with firm bottom and moderate current.

Status: *Endangered* in the state, probably *Extirpated* from the Swannanoa River. This species was described in 1945 from specimens collected some years earlier in the Swannanoa. It is unlikely that it still occurs in this river, which has been treated harshly in recent years. A current record from the South Toe River attests to the presence there of this very rare and poorly documented darter.

References: Fowler, H. W. 1945. A study of the fishes of the southern Piedmont and Coastal Plain. Monogr. Acad. Nat. Sci. Phila. 7, Philadelphia, PA. 408 pages.

PISCES; ACIPENSERIFORMES; POLYODONTIDAE
(Paddlefishes)

Polyodon spathula (Walbaum)

PADDLEFISH

Description: A large, scaleless fish with the snout greatly prolonged into a broad, depressed blade, widest toward the tip. The length of this "paddle" anterior to the ventral mouth is about a third the total length. The species exceeds 1.8 m (6 ft.) in length, and 67.5 kg (150 lb.) in weight. See Eddy (1957, p. 37) for a line drawing.

Distribution: Range -- large rivers of the Mississippi basin; formerly the Great Lakes.

North Carolina -- questionable in the French Broad system.

Habitat and Mode of Life: The paddlefish inhabits the open waters of large, murky rivers and flood-plain lakes. It feeds by straining micro-organisms from water and silt through the ventral mouth and efficient gill-rakers.

Status: *Endangered*. This fish may not actually occur in North Carolina. Cope (1870) stated that it ascended the French Broad to Asheville, but there are no specimens in existence and no recent records. It occurs in some of the Tennessee reservoirs, and may visit the French Broad on occasion.

Remarks: The paddlefish, and a relative found in China, represent the only living examples of this primitive and ancient group of fishes.

References: Eddy (1957); see list following introduction.
Cope, E. D. 1870. A partial synopsis of the fishes of the fresh waters of North Carolina. Proc. Amer. Philosoph. Soc. 11:448-495.

PISCES; OSTEOGLOSSIFORMES; HIODONTIDAE
(Mooneyes)

Hiodon tergisus Lesueur

MOONEYE

Description: Adults are silvery in color and usually 30 cm (1 ft.) or so in length. The eye is large in a small head; the body is deeply compressed but has no keel on the belly. There is a single dorsal fin with 11-12 rays, and the anal fin is long, its base more than twice that of the dorsal fin. See Smith (1907, p. 118) for a line drawing.

Distribution: Range -- tributaries of Hudson's Bay south through Great Lakes, Mississippi system to Missouri and Alabama, including Tennessee system.

North Carolina -- French Broad River.

Habitat and Mode of Life: The mooneye is a fish of lakes and large rivers, preferably with clear water. Its numbers have decreased over its entire range as streams have borne an increasing silt burden.

Status: *Endangered*. We have only three records from North Carolina, all from the French Broad. An old specimen was sent to the U. S. National Museum of Natural History in 1902 from Bowman's Bluff, a second specimen was taken at the mouth of Big Laurel Creek in 1972 by a party from the N. C. State Museum of Natural History, and the third was taken from below Hot Springs by Spears.

Remarks: This is not a particularly choice food fish, but is of special biological interest. It is one of the most primitive of the higher bony fishes, and has an unusual type of retina in the eye.

References: Smith (1907); see list following introduction.

PISCES; CYPRINIFORMES; CYPRINIDAE
(Minnows and Carps)

Hybopsis monacha (Cope)

SPOTFIN CHUB

Description: A small minnow, about 7.5 to 10 cm (3 to 4 in.) long. The inferior horizontal mouth has a small barbel in the corners where the upper and lower lips meet. The general color is greenish above and silver below. There is a large, dark spot at the base of the caudal, dark pigment on the posterior rays of the dorsal fin, and a tendency toward a silvery lateral stripe. See Eddy (1957, p. 111) for a line drawing.

Distribution: Range -- formerly upper Tennessee River system, Alabama to Virginia and North Carolina. Presently known in Emory River system, Tennessee, and Little Tennessee, North Carolina.

North Carolina -- Little Tennessee, between Franklin and Fontana Reservoir (Etnier, pers. comm., 13 November 1975; Jenkins, pers. comm., 17 November 1975).

Habitat and Mode of Life: The spotfin chub prefers shallow gravel riffles with moderate to fast currents in medium sized streams and small rivers.

Status: *Endangered*. Old records indicate its occurrence in the Swannanoa River near Asheville, and Spring Creek at Hot Springs in the French Broad (Smith 1907). Since intensive recent collecting in these areas has failed to reveal it, the species is presumed a victim of pollution here. Recent proof that it still persists upstream from Fontana Reservoir in the Little Tennessee is a happy note, but its future must be viewed with concern.

Editor's Note: On 12 January 1977 the spotfin chub was proposed for inclusion in the federal list as *Threatened* throughout its range (*Federal Register* 42(8):2507-2515). Part of its proposed critical habitat is, "Main channel Little Tennessee River, North Carolina above Fontana Lake in Swane (sic) and Macon Counties."

References: Eddy (1957); see list following introduction.
Hubbs, C. L., and W. R. Crowe. 1956. Preliminary analysis of the American cyprinid fishes, seven new, referred to the genus *Hybopsis*, subgenus *Erimystax*. Occ. Pap. Mus. Zool. Univ. Mich. 578:1-8.

PISCES; ATHERINIFORMES; CYPRINODONTIDAE
(Killifishes)

Fundulus waccamensis Hubbs and Raney

WACCAMAW KILLIFISH

Description: A small, minnow-like fish reaching a length of about 70 mm (2 3/4 in.). The mouth is superior and adapted for feeding on the surface. The ground color is light brown, and there are vertical dark bars on the sides. See Hubbs and Raney (1947, Plate 1) for a photograph.

Distribution: North Carolina endemic. Lake Waccamaw, Columbus Co., Phelps Lake, Washington Co.

Habitat and Mode of Life: This is a species of open water over firm sandy bottom, often at the outer edge of emergent rushes along shore. It is adapted for feeding on small insects and their larvae at the water's surface.

Status: *Endangered*. This killifish is presently common in both lakes. The danger to it lies in the fate of the lakes which are considered fragile habitats. The extensive silting which has occurred in Phelps Lake over the last decade as a result of clearing and farming the surrounding land has been discussed earlier. If this is not checked the entire bottom will be covered with shifting detritus which will be an unfavorable situation for emerging aquatic insects, undoubtedly a major food source for the killifish. In Lake Waccamaw it is feared that domestic effluents will so enrich the lake that massive algal blooms and eutrophication will be the result. This will eventually choke the system and cause periodic oxygen depletion. Preventive measures should be taken immediately to prevent further deterioration of the lakes and adjoining properties.

References: Frey, D. G. 1949. Morphometry and hydrography of some natural lakes of the North Carolina Coastal Plain: The bay lakes as a morphometric type. J. Elisha Mitchell Sci. Soc. 65(1):1-37.
_____. 1950. Carolina bays in relation to the North Carolina Coastal Plain. J. Elisha Mitchell Sci. Soc. 66(1):44-52.
_____. 1951. The fishes of North Carolina's bay lakes and their intraspecific variation. J. Elisha Mitchell Sci. Soc. 67(1):1-44.
Hubbs, C. L., and E. C. Raney. 1946. Endemic fish fauna of Lake Waccamaw, North Carolina. Misc. Publ. Mus. Zool. Univ. Mich. 65, Ann Arbor, MI. 31 pages.

PISCES; ATHERINIFORMES; ATHERINIDAE
(Silversides)

Menidia extensa Hubbs and Raney

WACCAMAW SILVERSIDE

Description: A long, slim, almost transparent, minnow-like fish with a silver stripe along each side. Adults are around 6.5 cm (2 1/2 in.) long. The body is laterally compressed, with a very large eye, superior mouth, and sharply angled jaw. The scales are very small and tissue thin. There are two dorsal fins, widely separated, and the first is supported by thin spines. See Hubbs and Raney (1946, Plate 1) for a photograph.

Distribution: North Carolina endemic. Lake Waccamaw.

Habitat and Mode of Life: The Waccamaw silverside inhabits open water, where it usually travels in schools and may often be seen flipping out of the water. Primary food is probably surface invertebrates, mostly insects.

Reproduction: Spawning probably occurs in the spring. The eggs are equipped with adhesive filaments, and apparently attach to objects in the water.

Status: *Endangered*. This species, like the Waccamaw killifish, is dependent upon the lake remaining in its present state. The problems are discussed in the Introduction, and in the account of the preceding species.

Remarks: A closely related species, the tidewater silverside, *M. beryllina*, occurs in Lake Phelps and in brackish waters along the coast.

Reference: Hubbs, C. L., and E. C. Raney. 1946. Endemic fish fauna of Lake Waccamaw, North Carolina. Misc. Publ. Mus. Zool. Univ. Mich. 65, Ann Arbor, MI. 31 pages.

PISCES; PERCIFORMES; PERCIDAE
(Perches)

Etheostoma jessiae (Jordan and Brayton)

BLUESIDE DARTER

Description: A small darter reaching a length of about 50 mm (2 in.) with the body moderately deep and compressed. Several scales along the lateral line lack pores. The breeding male in life is chestnut above with about nine squarish blue blotches on the sides, and a chestnut wash on the lower sides. A narrow orange band is present on the first dorsal fin, and the second dorsal and anal fins are speckled with dark and gold. Females and non-breeding males are less colorful.

Distribution: Range -- upper Tennessee River system.

North Carolina -- only known from Mills River in French Broad system.

Habitat and Mode of Life: In North Carolina the blueside darter has been found where the Mills River is about 18 m (60 ft.) wide, and from 8 to 10 cm to about a meter deep. The bottom is of boulders, rubble, sand and silt, and the water of the highest quality. We have no reports on its reproductive or feeding habits.

Status: *Endangered*. This darter is both local and rare, and little known. Only three specimens have been taken in the state and those in separate collections. Other more western species have been confused with this form.

References: Menhinick, et al. (1974); see list following introduction.

Jordan, D. S., and A. W. Brayton. 1878. Contributions to North American ichthyology No. 3. A. On the distribution of the fishes of the Alleghany region of South Carolina, Georgia, and Tennessee, with descriptions of new or little known species. Bull. U. S. Nat. Mus. 12: 1-95.

Etheostoma perlongum (Hubbs and Raney)

WACCAMAW DARTER

Description: An elongate form of the Johnny darter, from which it differs in having more vertebrae and lateral line scales. Adults attain a length of 7.5 cm (3 in.). It is a generally pale fish, with W-shaped lateral markings, light bands on the dorsal fin, and a bar below the eye. See Hubbs and Raney (1946, Plate 1) for a photograph.

Distribution: North Carolina endemic. Lake Waccamaw and a nearby roadside ditch.

Habitat and Mode of Life: This darter inhabits fine-grained sandy bottoms, with or without aquatic vegetation.

Status: *Endangered*. The Waccamaw darter is much less common than the other Waccamaw fishes of concern, the killifish and the silverside. Unlike them, it is a bottom form and would be very sensitive to an overload of detritus. However, it may not be absolutely confined to the lake, since we have a specimen from a roadside ditch near Old Dock, some 12 km (8 mi.) below the lake. It may also occur in the upper reaches of the Waccamaw River. Nevertheless, because of its limited distribution and bottom-dwelling habits, we have placed it in this category.

References: Cole, C. F. 1957. The taxonomy of the percid fishes of the genus *Etheostoma*, subgenus *Boleosoma*, of the eastern United States. Unpub. PhD dissert., Cornell Univ., Ithaca, NY. 367 pages.
Hubbs, C. L., and E. C. Raney. 1946. Endemic fish fauna of Lake Waccamaw, North Carolina. Misc. Publ. Mus. Zool. Univ. Mich. 65, Ann Arbor, MI. 31 pages.

PISCES; CYPRINIFORMES; CYPRINIDAE
(Minnows and Carps)

Phenacobius teretulus Cope

KANAWHA MINNOW

Description: A minnow about 7.5 cm (3 in.) long, having an inferior, crescent-shaped mouth with prominent, fleshy, papillose lips like a sucker. The ventral surface is horizontal, the dorsum arched, and the head slightly depressed. There is a dark lateral stripe, but no prominent spot at the base of the caudal fin. The breast has scales. See Eddy (1957, p. 87) for a line drawing.

Distribution: Range -- Kanawha River system, Virginia and West Virginia; New River of Blue Ridge.
North Carolina -- New River watershed.

Habitat and Mode of Life: The Kanawha minnow inhabits clear to relatively clear waters of larger streams.

Status: *Threatened.* This species is flourishing at present, but is placed in jeopardy by proposed impoundment of the upper New River, Virginia. Since it is restricted to the Blue Ridge province, most of its range will be affected.

References: Eddy (1957); see list following introduction.
Jenkins, R. E., E. A. Lachner, and F. J. Schwartz. 1971. Fishes of the central Appalachian drainages: their distribution and dispersal. In: P. Holt (Ed.). The Distributional History of the Biota of the Southern Appalachians. Part III: Vertebrates. Res. Div. Monogr. 4, Va. Polytech. Inst. and State Univ., Blacksburg, VA. pp. 43-117.
Menhinick, E. F., T. M. Burton, and J. R. Bailey. 1974. An annotated checklist of the freshwater fishes of North Carolina. J. Elisha Mitchell Sci. Soc. 90(1):24-50.

PISCES; SILURIFORMES; ICTALURIDAE
(Freshwater Catfishes)

Noturus gilberti Jordan and Evermann

ORANGEFIN MADTOM

Description: A slender madtom about 7.5 to 10 cm (3 to 4 in.) long, with a dark, light margined caudal fin which is orange in life. The mouth is very wide and flaring, and the outer corners of the lips are as wide as the head. The margined madtom, *N. insignis*, which occurs with this species, has a light caudal fin with dark edge. See Taylor (1969, Plate 9) for a photograph, and Eddy (1957, p. 154) for a line drawing.

Distribution: Range -- upper Roanoke River system and headwaters of James River.
North Carolina -- Dan River.

Habitat and Mode of Life: The orangefin madtom is a fish of fast riffles over rubble and gravel.

Reproduction: Spawning probably occurs at night in early spring, perhaps extending into the fall. A nest is made in a cavity, gravel, or under some object, and the male probably guards the eggs and early young.

Status: *Threatened*. This rare and geographically limited species has been taken only three times in the state, all single specimens from the Dan River. This section of the river is clean and cool and considered marginal trout water since it derives from a subsurface water draw-off from a reservoir some miles above. However, we understand that plans are being formulated for construction of another dam downstream in Virginia. This would almost certainly eliminate the species from our fauna.

References: Eddy (1957); see list following introduction.
Taylor, W. R. 1969. A revision of the catfish genus *Noturus* Rafinesque with an analysis of higher groups in the Ictaluridae. U. S. Nat. Mus. Bull. 282, Washington, DC. 315 pages.

PISCES; PERCIFORMES; PERCIDAE
(Perches)

Etheostoma kanawhae (Raney)

KANAWHA DARTER

Description: A stocky darter about 9 cm (3 1/2 in.) total length. The sides have about nine vertical dark bars, some of which join on the upper sides to form five or six dorsal saddles. In breeding males the posterior lateral bars are green, separated by orange red bars which extend to the head and suffuse the lower sides and gill membranes with similar color. This merges to yellow above and on the chin. The anterior dorsal fin is brightly banded with greenish yellow spots near the body, outwards through clear, green, and bright orange red bands. Females, young, and off-season males lack most or all of the bright colors. See Raney (1941) for a complete description.

Distribution: Range -- Blue Ridge section of upper New River.
North Carolina -- entire New River.

Habitat and Mode of Life: This species is found in riffle portions of larger streams and the lower portions of their tributaries.

Status: *Threatened*. Although common and flourishing at present, most of the Kanawha darter's habitat would be destroyed by proposed dams, hence its status.

References: Raney, E. C. 1941. *Poeciliichthys kanawhae*, a new darter from the upper New River system in North Carolina and Virginia. Occas. Pap. Mus. Zool. Univ. Mich. 434:1-16.

Percina caprodes (Rafinesque)

LOGPERCH

Description: Very similar to the blotchside logperch, but with more bars on the side (about 15-20) and these narrow and vertical. The soft dorsal rays number 15-17 instead of 13-14. See Smith (1907, p. 254) for a line drawing, and Smith-Vaniz (1968, p. 191) for a photograph.

Distribution: Range -- Saskatchewan to eastern Quebec, northcentral U. S. to Vermont, south in Mississippi system to Rio Grande.

North Carolina -- French Broad River near Laurel Creek; questionable in Nolichucky River.

Habitat and Mode of Life: The logperch frequents riffle areas of larger streams and rivers. Aquatic insects and their larvae, notably midges and mayflies, appear to be the common food of the species. The young feed on small crustaceans. The species also consumes fish eggs.

Reproduction: Spawning occurs in the spring, and apparently requires at least some current. The males are territorial at this time. The eggs are deposited in gravel.

Status: *Threatened*. This is another very rare darter in the state, as attested by the paucity of records. The recent collection of the species by personnel from the North Carolina State Museum of Natural History leads us to consider it *Threatened* rather than *Endangered*. We hope its rarity here is more apparent than real, and due to inadequate sampling. Other records from the French Broad and Nolichucky Rivers are not supported by extant specimens, and it is not certain which of the logperch species is involved.

References: Menhinick et al. (1974), Smith (1907); see list following introduction.
Forbes, S. A., and R. E. Richardson. 1920. The Fishes of Illinois. Second edition. Nat. Hist. Survey Illinois, Springfield, IL. 357 pages, 103 maps.
Smith-Vaniz, W. F. 1968. Freshwater Fishes of Alabama. Agri. Exp. Sta., Auburn Univ., Auburn, AL. 211 pages.

Percina squamata (Gilbert and Swain)

OLIVE DARTER

Description: A slim, sharp-nosed darter with about 10 rounded to horizontally oblong lateral blotches and about 10 dark dorsal saddles. The general color is olive, with a submarginal orange band on the first dorsal fin of breeding males. At the base of the caudal fin is a poorly defined blotch with a black dot behind it, and there is a black humeral spot. The species attains a length of about 12.5 cm (5 in.). For the original description see Gilbert (1887).

Distribution: Range -- headwaters of Tennessee River.
North Carolina -- French Broad, Toe, and Hiwassee rivers.

Habitat and Mode of Life: The preferred habitat of the olive darter appears to be deep riffles in large streams, which makes it a most difficult species to collect.

Status: *Threatened*. This species is rare everywhere. Because its habitat is very difficult to sample, however, it may eventually turn out to be more abundant than is currently supposed. Riffle species, on the other hand, are very susceptible to deterioration of water quality, and the few records for North Carolina relegate it to this status. Six specimens are known from the state.

References: Gilbert, C. H. 1887. Description of new and little known theostomids. Proc. U. S. Nat. Mus. 10:47-64.
Menhinick, E. F., T. M. Burton, and J. R. Bailey. 1974. An annotated checklist of the freshwater fishes of North Carolina. J. Elisha Mitchell Sci. Soc. 90(1):24-50.

Discussion

Marc Imlay: I notice that last year, in a USGS survey, the pH of the Hiwassee dropped to 5.4 for a month or two, just about the middle of the river, I'm not sure of the exact location. But, for the two or three years before it was up in the 6's. I don't know what it's caused by, but it's ominous.

Bailey: I would have no way of knowing what happened. I haven't seen the Hiwassee for several years myself.

Dave Etnier: Where was this water survey table, Marc?

Imlay: USGS survey of . . .

Etnier: Is this below the mouth of the Ocoee . . . the copper outfit which is still polluting but not as bad . . .

Tom Quay: What about the effects of the First Colony Farms type of thing and in the big sounds, maybe you and Frank Schwartz could both comment on that, it's just starting. Hasn't got as far as Lake Phelps yet.

Bailey: What hasn't gotten as far as Lake Phelps? The silt has, I mean the blown dust.

Quay: It already has?

Bailey: Well, it's right at the margin. I mean we have thousands, now, tens of thousands of acres which are bare dirt surface around Lake Phelps.

Freshwater Fishes -- Discussion

Quay: I mean the drainage hasn't gone off into the fresh and estuarine waters as yet.

Bailey: No, Lake Phelps itself drains out through a canal which used to be the access route of the Somerset Plantation. I don't know that there is another outlet from it. There would be no way for it to carry the silt out through that canal. The canal is dry most of the time and only occasionally does it fill up. It's probably a matter of 15 miles or more from the edge of the lake to the sound -- Pamlico Sound.

Ben Sanders: I wondered if your Committee had addressed the problem, or perhaps it's not a problem, of displacement of brook trout by stocked rainbow and brown trout anywhere in the mountains of North Carolina?

Bailey: We didn't consider that at all, and at this late date I don't think there is any useful purpose served in trying to control it. In the future it might be a fine management policy to limit introduction of new fishes -- of only one species, for instance brook trout -- into its native waters and keep the others out. We could never restore native populations of brook trout.

Sanders: All of the existing native brook trout populations are invaded, then? There are no . . .

Bailey: Absolutely. All those species have had access to all of the water sheds that will support them, but we did not consider that problem.

Amphibians and Reptiles

Introduction
by
Richard C. Bruce

Amphibians and reptiles represent two separate classes of vertebrates that can conveniently be considered together. The former group includes the salamanders, frogs, and toads; the latter the crocodilians, turtles, lizards, and snakes. Collectively they constitute the herpetofauna of a region. North Carolina has a rich herpetofauna, a circumstance explained in part by the diversity of habitats and the pronounced physiographic and climatic gradient between mountains and seacoast. There are 157 species and subspecies of amphibians and reptiles known to occur in the state, and this includes 137 full species. The numbers in each subgroup are:

<u>Group</u>	<u>Number of Species</u>	<u>Number of Species and Subspecies</u>
Amphibians	(69)	(78)
Salamanders	39	47
Frogs and Toads	30	31
Reptiles	(68)	(79)
Crocodilians	1	1
Turtles	19	21
Lizards	10	10
Snakes	38	47
Total	✓ 137	157

The distributions of amphibians and reptiles in North Carolina show strong patterns of zonation that become apparent when the major taxonomic subdivisions are considered separately. Thus, among the reptiles there is but one crocodilian, the American Alligator, and it is restricted to the Coastal Plain. Five of the 21 turtles are marine species that occasionally visit our coastal waters and estuaries; of the 16 remaining forms, 13 occur in the Coastal Plain, 9 in the Piedmont, and 6 in the Blue Ridge. However, only two species, the Snapping Turtle and Box Turtle, are common and widely distributed in the mountains. On a numerical basis the lizards show a lesser degree of zonation, with 8 of the 10 species occurring in all three physiographic provinces of the state. In the Blue Ridge, however, most of the lizards have localized distributions at low elevations. Of the 47 species and subspecies of snakes in North Carolina, the Coastal Plain, Piedmont, and Blue Ridge have 40, 27, and 23 forms, respectively; once again, many have more restricted ranges in the mountains.

Among the amphibians, the frogs and toads show zonation similar to that of the reptiles, with 27 species and subspecies in the Coastal Plain, and 11 each in the Piedmont and Blue Ridge. The general pattern is reversed with the salamanders: 33 of the state's 47 forms inhabit the Blue Ridge, with 16 and 21 in the Piedmont and Coastal Plain, respectively. Thus, with the exception of the salamanders, the general distributional

pattern of the North Carolina herpetofauna is one of progressive subtraction in the interior of the state from a rich Coastal Plain assemblage.

Examination of the distributions of North Carolina amphibians and reptiles over their entire ranges reveals other geographic patterns. Many species that occur statewide are widely distributed throughout eastern United States. The Snapping Turtle, Five-lined Skink, Black Racer, Spotted Salamander, and Spring Peeper can be cited as examples. In contrast, many of the amphibians and reptiles restricted to the eastern section of North Carolina are Gulf and South Atlantic Coastal Plain species that reach the northern limits of their ranges in eastern North Carolina, or in adjacent parts of Virginia. Included in this category are the Black Swamp Snake, Pinewoods Snake, and Ornate Chorus Frog, as well as numerous other species. Other Coastal Plain forms, like Mabee's Salamander, Many-lined Salamander, and Brimley's Chorus Frog, occur only in the Atlantic Coastal Plain, and have their centers of distribution or the greater part of their ranges in North Carolina.

At the opposite extreme, a smaller assemblage consists of northern forms that extend southward in the Appalachians and reach the southern ends of their ranges in western North Carolina or in the mountains of adjacent states. Examples of this group are the Milk Snake, Smooth Green Snake, and Wood Frog. The Blue Ridge of North Carolina also includes numerous species of lungless salamanders restricted to the cool, moist forests of the Southern Appalachians, with their centers of distribution in western North Carolina.

Finally, a particularly interesting group of species, of which the Bog Turtle, Coal Skink, and Pine Barrens Treefrog may be noted as examples, have relictual distributions; their ranges in eastern North America, apparently continuous in previous ages, are now broken into a number of scattered and isolated units, including populations in some parts of this state.

The herpetofauna of North Carolina has been of interest to biologists from both within and without the state for many years, and active, long-standing research programs have been in effect at the N. C. State Museum of Natural History and many of the state's universities and colleges. Thus, the fauna is relatively well-known, especially certain groups like the lungless salamanders of the mountains. However, since amphibians and reptiles are generally secretive animals, basic information on the distribution and ecology of many is lacking.

Of the 157 forms known to occur in North Carolina, we have designated 29 as deserving special consideration. Nine have been assigned to the *Undetermined* status category. Most of these are peripheral species with limited ranges in North Carolina and have not yet been adequately studied in the state. Additional field work is needed to determine their distributions and the status of their populations. The five sea turtles, all listed as *Endangered* in the state, represent a special group of essentially tropical species whose survival will largely depend on international cooperation among those countries where the turtles nest and are most seriously threatened by human depredation. Of the remaining fifteen species, variously listed as *Endangered*, *Threatened*, or of *Special Concern*, most are restricted to the Coastal Plain or Mountains. As noted in the individual accounts, nearly all of these occur to some extent on public lands in North Carolina, including National Parks and Seashores, National Forests, State Parks, Military Bases, and others. Such areas ought to be

recognized as the focal points in our conservation efforts with these species, particularly in regard to the several rare species that are individually dangerous to man (American Alligator, Diamondback Rattlesnake, Coral Snake), and that may only survive in North Carolina if provided with large wilderness areas in the lower Coastal Plain. Our listing also includes several aquatic species of large salamanders, such as the endemic Neuse River Waterdog in the east and the Hellbender in the mountains, that require clean, flowing water and are threatened by pollution and impoundment.

Although we have not identified cluster areas as such, the lower Coastal Plain (including the Outer Banks), the Sandhills, and the Blue Ridge Province are the more important areas of the state with regard to the welfare of rare species of amphibians and reptiles. Thus, the Outer Banks is the primary habitat of two unusual snakes, the Carolina Salt Marsh Snake (also found in certain brackish areas on the adjacent mainland), and the Outer Banks Kingsnake. Both are of uncertain taxonomic status. Other sections of the lower Coastal Plain harbor the American Alligator, Coral Snake, and Eastern Diamondback Rattlesnake. The Pine Barrens Treefrog occurs across the southern part of the Coastal Plain, including the Sandhills, and the latter area contains populations of the Tiger Salamander, Copher Frog, and Coral Snake. Most of the remaining species of concern are centered in the Blue Ridge. Many of these are salamanders, but the mountain assemblage also includes the Bog Turtle, Coal Skink, Smooth Green Snake, and Mountain Chorus Frog.

It is obvious that management directed toward preservation requires knowledge of a species' biology. A few of the species on our list, like the Green Salamander, have been intensively studied in the state. Several others are now being actively investigated by biologists (e.g., Bog Turtle, Coal Skink, Mole Salamander), but most are relatively poorly known. Thus, a continuing effort in basic research is called for, in coordination with management efforts to maintain appropriate habitats and conditions for survival of these interesting and important members of our state's fauna.

References

- Brimley, C. S. 1939-43. Amphibians and reptiles of North Carolina. Carolina Biological Supply Company, Elon College, NC.
- Catalogue of American Amphibians and Reptiles (Cat. Amer. Amphib. Rept.). 1963 *et seq.*, American Society of Ichthyologists and Herpetologists. 1971 *et seq.*, Society for the Study of Amphibians and Reptiles.
- Conant, R. 1975. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. Peterson Field Guide Series, Houghton Mifflin Co., Boston, MA. 429 pages.
- DePoe, C. E., J. B. Funderburg, and T. L. Quay. 1961. The reptiles and amphibians of North Carolina: a preliminary check list and bibliography. J. Elisha Mitchell Sci. Soc. 77:125-136.
- Huheey, J. E., and A. Stupka. 1967. Amphibians and Reptiles of Great Smoky Mountains National Park. Univ. Tenn. Press, Knoxville, TN. 98 pages.
- Palmer, W. M. 1974. Poisonous Snakes of North Carolina. N. C. State Mus. Nat. Hist., Raleigh, NC. 22 pages.

Amphibians and Reptiles -- Species List

Species List

Species	Status
Amphibia	
Urodela	
<i>Ambystoma talpoides</i> , Mole Salamander 318	Special Concern
<i>Ambystoma t. tigrinum</i> , Eastern Tiger Salamander 329	Undetermined
<i>Aneides aeneus</i> , Green Salamander 319	Special Concern
<i>Cryptobranchus a. alleganiensis</i> , Hellbender 316	Special Concern
<i>Eurycea l. longicauda</i> , Long-tailed Salamander 321	Special Concern
<i>Hemidactylium scutatum</i> , Four-toed Salamander 329	Undetermined
<i>Necturus m. maculosus</i> , Mudpuppy 329	Undetermined
<i>Necturus lewisi</i> , Neuse River Waterdog 317	Special Concern
<i>Plethodon d. dorsalis</i> , Zigzag Salamander 329	Undetermined
<i>Plethodon longicrus</i> , Crevice Salamander 312	Threatened
<i>Plethodon wehrlei</i> , Wehrle's Salamander 329	Undetermined
<i>Plethodon welleri</i> , Weller's Salamander 322	Special Concern
Anura	
<i>Hyla andersoni</i> , Pine Barrens Treefrog 313	Threatened
<i>Pseudacris brachyphona</i> , Mountain Chorus Frog 329	Undetermined
<i>Rana anaxolata capito</i> , Carolina Gopher Frog 323	Special Concern
Reptilia	
Crocodylia	
<i>Alligator mississippiensis</i> , American Alligator 310	Endangered
Testudines	
<i>Caretta c. caretta</i> , Atlantic Loggerhead 303	Endangered
<i>Chelonia m. mydas</i> , Atlantic Green Turtle 304	Endangered
<i>Clemmys muhlenbergi</i> , Bog Turtle 314	Threatened
<i>Dermochelys c. coriacea</i> , Atlantic Leatherback 307	Endangered
<i>Eretmochelys i. imbricata</i> , Atlantic Hawksbill 305	Endangered
<i>Lepidochelys kempfi</i> , Atlantic Ridley 306	Endangered
<i>Trionyx s. spiniferus</i> , Eastern Spiny Softshell 329	Undetermined
Squamata, Lacertilia	
<i>Eumeces anthracinus</i> , Coal Skink 325	Special Concern
Squamata, Serpentes	
<i>Crotalus adamanteus</i> , Eastern Diamondback Rattlesnake	Endangered
<i>Lampropeltis getulus sticticeps</i> , Outer Banks 308	
Kingsnake 326	Special Concern
<i>Micrurus f. fulvius</i> , Eastern Coral Snake 327	Special Concern
<i>Natrix sipedon williamogensi</i> , Carolina Salt	
Marsh Snake 329	Undetermined
<i>Opheodrys v. vernalis</i> , Eastern Smooth Green Snake 329	Undetermined

SPECIES ACCOUNTS

REPTILIA; TESTUDINES; CHELONIIDAE
(Modern Sea Turtles)

Caretta caretta caretta (Linnaeus)

ATLANTIC LOGGERHEAD

Description: A large sea turtle with a reddish brown to brown carapace (upper shell) and yellowish plastron (lower shell). The forelimbs are paddle-shaped with two claws. Mature males have a tail longer than the hind flipper, while the tail of females is shorter. Maximum known size for the species is around 450 kg (1,000 lb.), but 135 kg (300 lb.) and a carapace length of 75 cm (30 in.) is more usual. It attains weights to 193 kg (430 lb.) in North Carolina. See Conant (1975, Plate 11) for distinctions between this and other sea turtles, and Ernst and Barbour (1972, pp. 231-238) for a full account of the species.

Distribution: Range -- Nova Scotia to Argentina, Caribbean, Gulf of Mexico.

North Carolina -- found on entire coast April to mid-November, vacating estuaries and rivers for winter as temperatures drop.

Habitat and Mode of Life: The Loggerhead frequents the open ocean, estuaries, and mouths of rivers, and females come ashore to lay eggs. It feeds on fishes, mollusks, sponges, jellyfish, squid, other animals, and several marine plants.

Reproduction: Nesting occurs just above high water on open beaches, usually seaward of dunes, from April to early October. Mating takes place in the water near nesting beaches. Recent U. S. nesting has been recorded as far north as Ocean City, Maryland, and New Jersey, but most frequently occurs at sites south of Cape Lookout, North Carolina. Seventy-one nests at Cape Romain, South Carolina, averaged 126 eggs, but numbers can vary from 64 to 341. The incubation period is 55 to 70 days, with 83-87% hatching success. Eggs are subject to predation by a variety of creatures, including dogs, hogs, crabs, raccoons, and humans. Hatchlings fall prey to a wide variety of animals, both on the beaches and in the water.

Status: *Endangered*. Accelerated destruction of beach nesting sites and heavy nest predation, especially by raccoons, have taken their toll of this species. Human use of meat and eggs has also contributed significantly to its decline. It is considered to be *Endangered* in other southeastern states, including Georgia, Maryland, and Mississippi, and is recognized as generally *Threatened* throughout the southeast.

References: Brimley (1939-43), Conant (1975); see list following introduction.
Ernst, C. H., and R. W. Barbour. 1972. Turtles of the United States. Univ. Press of Kentucky, Lexington, KY. 347 pages.
Fahy, W. E. 1954. Loggerhead turtles, *Caretta caretta caretta*, from North Carolina. Copeia No.2:157-158.

Author: Frank J. Schwartz.

Description: A medium-to-large marine turtle with a light to dark brown carapace having darker mottling. The plastron is yellowish. The carapace of the young is black to gray, with some brown on the margins of shell and flippers, and the plastron is dusky to white. The tail of mature males is equal to or longer than the hind flipper, shorter in females. The species is known to attain weights of 380 kg (850 lb.) and lengths of 1.5 m (5 ft.), but the general recent size is 135 kg (300 lb.) and a little over a meter (43 in.) carapace length. In North Carolina, wild specimens over 13.5 kg (30 lb.) are rarely taken. Captive young were reared to 42 kg (93 lb.) in six years. See Conant (1975, Plate 11) for distinctions between this and other sea turtles, and Ernst and Barbour (1972, pp. 207-221) for a full account of the species.

Distribution: Range -- essentially tropical waters; widely distributed between 35° N and 35° S latitudes; Western Atlantic from Massachusetts to Mar del Plata and Necochea, Argentina.

North Carolina -- once abundant at Beaufort, now occasional along entire coast and in sounds; young released in Florida have been recaptured in Pamlico Sound.

Habitat and Mode of Life: The Green Turtle frequents ocean and estuarine habitats, entering sounds and rivers in summer. It feeds in shallow water on algae, other vegetation, fish, shrimp, and a variety of other foods, and adults prefer vegetation, especially roots. Its carapace is usually encrusted with the barnacle, (Schwartz 1960).

Reproduction: This species is not known to nest within the state; closest breeding beaches are on the coasts of Florida and Bermuda. Elsewhere females may nest several times in a single season, and eggs number from 18 to 193, with a reported and apparently unusual maximum of 226. Incubation usually takes 45 to 60 days, with reported hatching successes ranging from 41-86%. The eggs and young are subject to high mortality.

Status: *Endangered*. Breeding sites in the Caribbean have been decimated by man and predators. The turtle is a widely used source of meat, eggs, and shell for ornaments, and it is undoubtedly one of the most valuable reptiles known. Recent attempts in Costa Rica, the Bahamas, and Florida to rear young for release have had limited success to date. Vast exploitation assures a very bleak future for this species unless regulations are instituted and enforced. It is considered *Endangered* throughout the southeastern United States.

References: Brimley (1939-43), Conant (1975); see list following introduction.
Brimley, C. S. 1926. Revised key and list of the amphibians and reptiles of North Carolina. J. Elisha Mitchell Sci. Soc. 42:75-93.
Carr, A., and D. Sweat. 1969. Long range recovery of tagged yearling *Chelonia* on the east coast of North Carolina. Biol. Cons. 1:341-342.

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- Ernst, C. H., and R. W. Barbour. 1972. Turtles of the United States. Univ. Press of Kentucky, Lexington, KY. 347 pages.
- Schwartz, F. J. 1960. The barnacle, *Platylepas hexastylus*, encrusting a green turtle, *Chelonia mydas mydas* from Chincoteague Bay, Maryland. Chesapeake Sci. 1(2):116-117.
- _____. 1961. Maryland Turtles. Md. Dept. Res. Ed., Educ. Ser. 50, Solomons, MD. 44 pages.

Author: Frank J. Schwartz.

Eretmochelys imbricata imbricata (Linnaeus)

ATLANTIC HAWKSBILL

Description: A medium-sized marine turtle with an amber carapace marked with streaks of red, yellow, brown, and black. This "tortoise-shell" pattern is particularly obvious in smaller, younger individuals, and the carapace of larger specimens is a darker greenish brown. The plastron is yellow, often with black areas, especially in young individuals. Wild adults may attain weights of 36 kg (80 lb.), but usually weigh 15-16 kg (35 lb.). The largest recorded North Carolina specimen weighed 20 kg (45 lb.), and the largest known specimen (from the Cayman Islands) weighed 126 kg (280 lb.). See Ernst and Barbour (1972, pp. 222-230) for illustrations and a full account.

Distribution: Range -- tropical parts of Western Atlantic; known from Massachusetts to S Brazil.

North Carolina -- known from four specimens: two captured in ocean at sea buoy off Beaufort Bar, 3 July 1970 and 31 July 1973 (UNC collections), and two trawled at sea 14 October and 10 November 1975.

Habitat and Mode of Life: The Hawksbill is oceanic in North Carolina, and none are known from sounds or rivers. Elsewhere it frequents rocky and coral areas, estuaries, and narrow creeks. Recorded foods include jellyfish, coral, sponges, mollusks, barnacles and other crustaceans, and fish. They apparently prefer invertebrates. The young appear to be herbivorous.

Reproduction: Nesting is not known in North Carolina; the nearest known beaches are on the Florida coast. Other nesting beaches are widely distributed throughout the West Indies, Central America, and northern South America. In one area, 57 nests contained an average of 161 eggs (53 to 206). Incubation may take from 50 to 70 days. Eggs and young suffer predation from the same sources mentioned for other marine species.

Status: *Endangered*. This turtle is widely exploited for its carapace scutes, which are the famed "tortoise shell" of combs and eye-glass frames. The turtle and its eggs are hunted for food, although there is some indication that the animal concentrates toxins from poisonous

organisms on which it feeds, and human deaths have been reported from consuming its flesh. The Hawksbill is considered *Endangered* by the federal government and has some measure of protection. Exploitation continues, however, and its future is in doubt unless broader enforcement is attained.

References: Ernst, C. H., and R. W. Barbour. 1972. Turtles of the United States. Univ. Press of Kentucky, Lexington, KY. 347 pages.

Author: Frank J. Schwartz.

Lepidochelys kempii (Garman)

ATLANTIC RIDLEY

Description: A small-to-medium sea turtle with a dark gray or gray brown to olive green carapace, and white or yellow plastron. It attains weights to 48 kg (108 lb.), a carapace length of 69 cm (27 in.), and matures at about 60 to 75 cm (24 to 30 in.) length. Taxonomic problems exist as to the status of this turtle and the Pacific Ridley, *L. olivacea*. See Conant (1975, Plate 11) for distinctions between this and other sea turtles, and Ernst and Barbour (1972, pp. 239-248) for a full account.

Distribution: Range -- Nova Scotia to Brazil, with most occurrences in tropical Caribbean; also E European coast, Britain, and occasionally Mediterranean.

North Carolina -- formerly common at Beaufort during summer months and known off Cape Hatteras. Presently known from eight specimens captured late July and August 1970; '72, '73, '74 in Core Sound and North River, Carteret County.

Habitat and Mode of Life: The Ridley is found in high saline portions of sounds near the ocean in this state, and apparently prefers shallow water everywhere. It feeds on crabs, jellyfish, snails, clams, fish, and occasionally plants. Captives fed on penaeid shrimp and fish.

Reproduction: The species is not known to nest in North Carolina. Nesting occurs on Texas and Mexican beaches, especially on the Tamaulipas coast north of Tampico. Females come ashore during daylight hours in large groups to lay eggs. Clutches of eggs from 271 females averaged 110, with a range of 54 to 185. Incubation apparently takes 50 to 70 days. The nests and young are subject to the same predator pressures as those of other marine turtles.

Status: *Endangered*. Some authorities consider survival of the Ridley to be more tenuous than that of any other sea turtle. It has been depleted by capture for food, and the destruction of nests and breeding females. The species is considered *Endangered* by the U. S. government, and the Mexican government now affords protection to nesting females in Tamaulipas.

Remarks: The Atlantic Ridley is also known as the Bastard Turtle, and Kemp's Ridley Turtle.

References: Brimley (1939-43), Conant (1975); see list following introduction.

Ernst, C. H., and R. W. Barbour. 1972. Turtles of the United States. Univ. Press of Kentucky, Lexington, KY. 347 pages.

Hardy, J. D., Jr. 1962. Comments on the Atlantic ridley turtle, *Lepidochelys olivacea kempfi*, in the Chesapeake Bay. Chesapeake Sci. 3 (3):217-220.

Schwartz, F. J. 1961. Maryland Turtles. Md. Dept. Res. Ed., Ed. Ser. 50, Solomons, MD. 44 pages.

Author: Frank J. Schwartz.

Dermochelys coriacea coriacea (Linnaeus)

ATLANTIC LEATHERBACK

Description: This is the largest species of turtle known in the world today. Instead of a hard shell with horny plates the body is covered by a keeled, leathery skin. Its dorsal coloration is black or brown, occasionally with scattered white spots, and the plastron is whitish and ridged. The limbs are paddlelike and lack claws; those of the young are edged with yellow. Adults are known to weigh from 315 to 720 kg (700 to 1,600 lb.) and measure 118 to 185 cm (46 to 72 in.). There are taxonomic problems concerning a Pacific subspecies. See Ernst and Barbour (1972, pp. 249-255) for an account and illustrations.

Distribution: Range -- Atlantic Ocean from Newfoundland to Mar del Plata, Argentina. Widely distributed in tropical and subtropical seas, but nowhere plentiful.

North Carolina -- known from young of a single nesting at Cape Lookout, and seven adults. Four of latter caught in ocean on scallop grounds 10 km (16 mi.) SE Beaufort Bar: 360 kg (800 lb.), 27 March 1897; 315 kg (700 lb.), June 1935; 216 kg (480 lb.), 24 June 1968; and 313 kg (695 lb.), 22 May 1972. Another, 400 kg (890 lb.), off Bogue Banks, 1972; sixth, about 360 kg (800 lb.), in Neuse River near New Bern, Craven Co., 16 November 1975; and seventh, about 180 kg (400 lb.), Atlantic off Ocracoke, 6 January 1976.

Habitat and Mode of Life: An open-ocean species that occasionally moves into shallow bays, estuaries, and even river mouths. Females come ashore to lay eggs. The species feeds extensively on jellyfish, including the Portuguese man-of-war, and also eats sea urchins, young octopuses, tunicates, crustaceans, fish (especially those species associated with certain jellyfishes), and algae.

Reproduction: A single, apparently accidental, North Carolina nesting occurred near the Coast Guard Station, Cape Lookout, in June 1966. The number of eggs and hatchlings is unknown, and only a few were discovered. Normal nesting occurs April through November on beaches of Florida, the West Indies, Trinidad, northern South America, Central America, and Liberia. Clutch size varies from 50 to 170 eggs, and high percentages of abnormal, yolkless eggs are reported. The incubation period is apparently 53 to 74 days. Eggs and hatchlings are subject to heavy predation.

Status: *Endangered*. The Leatherback is nowhere abundant, but Carr (1967) considered its survival prospects to be the "least dreary" of any marine turtle. Although some nesting beaches are still looted, the adults are not generally sought for food. Some cosmetic purposes are served by their oil. Sharks attack Leatherbacks, and they are preyed upon by killer whales (Caldwell and Caldwell 1969). The species is classed as *Endangered* by the federal government.

References: Brimley (1939-43); see list following introduction.
Caldwell, D. K., and M. C. Caldwell. 1969. Addition of the leatherback sea turtle to the known prey of the killer whale, *Orcinus orca*. J. Mammal. 50:636.
Carr, A. F. 1967. So excellent a fishe. Natural History Press, Garden City, NY. 248 pages.
Ernst, C. H., and R. W. Barbour. 1972. Turtles of the United States. Univ. Press of Kentucky, Lexington, KY. 347 pages.

Author: Frank J. Schwartz.

REPTILIA; SQUAMATA; VIPERIDAE
(Pit Vipers)

Crotalus adamanteus Beauvois

EASTERN DIAMONDBACK RATTLESNAKE

Description: This huge snake, sometimes confused with the Timber or Canebrake Rattlesnake, is the only rattlesnake in southeastern United States with two prominent diagonal yellow lines on each side of the head. Body pattern consists of dark, diamond-shaped blotches with light centers and yellowish margins. A large rattle or enlarged "button" is present on the tip of the tail. It is the largest venomous snake in North America, reaching a maximum total length of about 2.4 m (8 ft.). Most adults in North Carolina, however, range from 1.2 to 1.5 m (4 to 5 ft.). Photographs are provided by Palmer (1974), and the species is treated in detail by Wright and Wright (1957) and Klauber (1972).

Distribution: Range -- SE North Carolina south in Coastal Plain throughout Florida, W to extr. E Louisiana.

North Carolina -- only in S Coastal Plain. Museum specimens from Brunswick, Carteret, Columbus, Craven, Cumberland, Duplin, New Hanover, Onslow, Pender and Robeson cos. Literature records (not supported by specimens but probably valid) from Jones and Sampson cos. Former range in North Carolina not known, but may have been similar to that of longleaf pine and wiregrass community, which once occupied much of the Coastal Plain south of Dismal Swamp. One record each exists for Cumberland (August 1930) and Robeson (September 1934) cos., and several other records prior to about 1945 have not been duplicated.

Habitat and Mode of Life: The species is closely associated with pine and wiregrass flatwoods intermingled with dense bays or pocosins. In such sections, abandoned farms with brush-grown fields often provide suitable habitat. It is a highly secretive snake and frequently hides in hollow logs, stump holes, and burrows of other animals. Rabbits constitute the principal food of adults; juveniles feed on rodents and similar smaller animals.

Reproduction: Nothing is known about the reproductive biology in North Carolina, and surprisingly little has been published concerning reproduction in other states. Most matings probably take place in the spring, and the young are usually born in August and September. Litters range from 7 to 18 young (Wright and Wright 1957), 30 to 36 cm (12 to 14 in.) in total length at birth (Conant 1975). Breeding potential in captivity is unknown. Most wild-caught adults fare poorly, but juveniles usually adjust readily, grow rapidly, and thrive under captive conditions. The number of North Carolina individuals currently in captivity is unknown but probably few. Some are maintained at the N. C. State Museum.

Status: *Endangered*. This animal in North Carolina is largely a species of uninhabited forested areas and its endangerment is irrevocably linked with the disappearance of these places. To what extent individual persecution adversely affects populations is not known. Certainly few of these snakes survive meetings with man, and the number of such encounters is probably directly proportional to accessibility and alteration of habitat. This rattlesnake occurs at the northern periphery of its range in or near Croatan National Forest (Carteret, Craven, and Jones counties), where its habitat could be preserved. Conservation efforts could also be made at Holly Shelter Wildlife Refuge, Pender County, and Camp Lejeune, Onslow County. Population size is not known, but it is doubtful that any area in the state supports a population density sufficient for detailed life history research. This snake was considered a species of *Special Concern* at the Workshop on Threatened and Endangered Vertebrates of the Southeast. Its status is of some concern in a number of southeastern states. The Eastern Diamondback Rattlesnake is one of the few North American snakes in which geographic variation has not been studied. Moreover, its life history, especially in the northern range, is virtually unknown. North Carolina populations are peripheral and therefore of considerable taxonomic, evolutionary, and other significance.

Remarks: Not even the most liberal conservationist would advocate protecting this dangerous animal in populated areas, and only through strict habitat preservation will this unique creature remain among the fauna of North Carolina.

References: Conant (1975), Palmer (1974); see list following introduction.

Klauber, L. M. 1972. Rattlesnakes: Their Habits, Life Histories, and Influence on Mankind. Second Edition, Univ. Calif. Press, Berkeley and Los Angeles, CA. Two volumes, 1,533 pages.

- Palmer, W. M., A. L. Braswell, and D. L. Stephan. 1974. Noteworthy herpetological records from North Carolina. *Bull. Md. Herpetol. Soc.* 10(3): 81-87.
- Wright, A. H., and A. A. Wright. 1957. Handbook of Snakes of the United States and Canada. Vol. 2, pp. 565-1105. Comstock Publ. Assoc., Ithaca, NY.

Author: William M. Palmer.

REPTILIA; CROCODYLIA; ALLIGATORIDAE
(Alligators and Caimans)

Alligator mississippiensis (Daudin)

AMERICAN ALLIGATOR

Description: This huge aquatic reptile is widely known and not likely to be confused with other animals. Adults range in total length from about 1.5 to 5.5 m (5 to 18 ft.). Very large individuals are now extremely rare, especially in the northern range. The largest specimen measured from North Carolina was 3.6 m (11 ft., 9 1/2 in.) in total length. Excellent photographs and a thorough discussion of the biology are provided by Neill (1971).

Distribution: Range -- approx. S shore Albemarle Sound, North Carolina, south in Coastal Plain throughout Florida, west to E Texas, north to S Arkansas and extr. SE Oklahoma. Apparently introduced or isolated population in extr. SE Texas. Former range extended to Dismal Swamp, in SE Virginia, and even today stragglers occasionally reported along northern shore of Albemarle Sound.

North Carolina -- E and S Coastal Plain to Albemarle Sound. Because of their large size, few alligators have been preserved in museums and most records are from literature or unpublished observations of competent observers, but museum specimens available from Brunswick, Carteret, Craven, New Hanover, and Onslow cos. Other records are known for Beaufort, Bladen, Columbus, Cumberland, Duplin, Lenoir, Pamlico, Pender, Pitt, Robeson, Sampson, Washington, and Tyrrell cos.

Habitat and Mode of Life: The Alligator occurs in coastal rivers, lakes, marshes, and estuaries. In the southeastern portion of the state, this reptile sometimes inhabits cypress ponds in flatwoods and sandhills. Prior to habitat disruption and extensive individual persecution, alligators "abounded in almost every major aquatic situation in the Coastal Plain, with the exception of smaller streams and well-isolated small ponds" (Neill 1971). Fishes, frogs, turtles, snakes, birds, and mammals comprise the Alligator's principal food.

Reproduction: Courtship and mating occur in the spring, nest building and egg laying in the late spring and summer. Nests, normally ranging from 46 to 76 cm (10' to 30 in.) high and 122 to 153 cm (48 to 60 in.) in

diameter, are constructed by the female from vegetable debris and soil, usually near the water. Eggs average about 7.6 X 4.4 cm (3 X 1 3/4 in.) and number from 28 to 52 per clutch (Neill 1971). A female sometimes guards the nest until the eggs hatch, usually from late July to early September. Hatchlings average about 22 cm (8 1/2 in.) in total length. Recently hatched young have been found in August and September; otherwise nothing is known about the reproductive biology in North Carolina. Alligators apparently breed readily in captivity when provided with adequate quarters, and reproductive success is similar to that found in wild populations (Joanen 1969; Joanen and McNease 1971). The number of North Carolina individuals in captivity is unknown.

Status: *Endangered*. This unique animal, considered *Endangered* by the U. S. Department of the Interior, is now protected by federal law. Collecting is allowed in several Louisiana parishes. In North Carolina, governmental lands known to support populations, and where habitat might readily be preserved, are Croatan National Forest (Carteret, Craven, and Jones counties) and Camp Lejeune Marine Base (Onslow County). High population densities occur in Ellis Lake (Craven County) and Orton Pond (Brunswick County), both of which are privately owned but with public trespass largely prohibited. A sizable population apparently also inhabits Warwick Bay (Robeson County), a privately owned refuge for waterfowl. Nevertheless, the Alligator is rare in most of North Carolina. Existing legislation, while protecting individuals from persecution, fails to control the extensive and deleterious modification of habitat which today represents the principal and most imminent threat to populations.

Because of their peripheral range in the state, and because so little is known about the natural history of northern populations, alligators in North Carolina are of considerable scientific interest.

References: Conant (1975); see list following introduction.

Joanen, T. 1969. Nesting ecology of alligators in Louisiana. Proc. S. E. Assoc. Game and Fish Comm. 23:141-151.

_____, and L. McNease. 1971. Propagation of the American Alligator in captivity. Proc. S. E. Assoc. Game and Fish Comm. 25:106-116.

Neill, W. T. 1971. The Last of the Ruling Reptiles. Columbia Univ. Press, N. Y., NY and London. 486 pages.

Authors: William M. Palmer and Alvin L. Braswell.

AMPHIBIA; URODELA; PLETHODONTIDAE
(Lungless Salamanders)

Plethodon longicrus Adler and Dennis

CREVICE SALAMANDER

Description: A large, handsome salamander with a black dorsum marked by variable amounts (a few small flecks to large blotches) of chestnut brown. There are scattered white flecks on the back, heavily concentrated on the sides of larger individuals. The venter is dark gray with scattered (profuse to scant) white spots or flecks. The soles of the feet are pink in adults and almost without pigment in juveniles. Adults are 13 to 22 cm (5 to 9 in.) in total length, and have 16 costal grooves (counting one each in the axilla and groin). The legs are long and well developed. The closely related Yonahlossee Salamander, *P. yonahlossee*, differs by having a broad chestnut brown dorsal band bordered by a light lateral stripe. The Slimy Salamander, *P. glutinosus*, is slightly smaller, has shorter legs, a darker throat, and lacks chestnut pigment. See Adler (1965) and Adler and Dennis (1962) for a full description, and Conant (1975, Plate 40) for comparative color illustrations.

Distribution: Range -- North Carolina endemic; recorded only in and near Rutherford Co. Type locality on NE slope of Bluerock Mountain near Bat Cave.

Habitat and Mode of Life: The Crevice Salamander inhabits the cool (about 15° C), moist, but not wet, crevices and environs of vertical surfaces of metamorphic rock outcrops (granite gneiss), at elevations from 430 to 790 m (1,400 to 2,600 ft.). It probably feeds on small arthropods and other invertebrates.

Reproduction: Specimens do not reach sexual maturity until about 70 mm (2 3/4 in.) in snout-vent length. No other data on reproductive biology are available.

Status: *Threatened*. This species probably arose by genetic drift (isolation of a small population by climatic conditions associated with the last glaciation). Its very restricted geographic range demands that it be given maximum protection. It probably never existed in large numbers and is still perilously close to becoming extinct. Only a few hundred specimens are in major United States museums.

References: Conant (1975); see list following introduction.
Adler, K. K. 1965. *Plethodon longicrus* Adler and Dennis. Cat. Amer. Amphib. Rept.:18.1. Amer. Soc. Ichthyol. Herpetol.
_____, and D. M. Dennis. 1962. *Plethodon longicrus*, a new salamander (Amphibia: Plethodontidae) from North Carolina. Spec. Publ. Ohio Herpetol. Soc. 4:1-14.
Highton, R. 1972. Distributional interactions among eastern North American salamanders of the genus *Plethodon*. Va. Polytech. Inst., Res. Div. Monogr. 4, Blacksburg, VA. pp. 139-188.

Author: Bernard S. Martof.

AMPHIBIA; ANURA; HYLIDAE
(Treefrogs)

Hyla andersoni Baird

PINE BARRENS TREEFROG

Description: This species, one of the most beautiful of North American frogs, is green with a prominent lavender stripe bordered by white on each side. The partly webbed toes have expanded terminal disks. Adults range in snout-vent length to about 5 cm (2 in.). A color illustration is provided by Conant (1975, Plate 47).

Distribution: Range -- apparently disjunct populations in S New Jersey, North and South Carolina, Georgia, and Florida panhandle. Current populations presumably relicts from considerably more widespread distribution in past.

North Carolina -- portions of Coastal Plain and along Fall Line. Museum specimens from Bladen, Cumberland, Harnett, Hoke, Johnston, Lee, Moore, Onslow, Sampson, and Wayne cos. Literature records (not supported by specimens but probably valid) from Duplin, Jones, Lenoir, Pender, Richmond, and Scotland cos. Former range in state unknown.

Habitat and Mode of Life: The Pine Barrens Treefrog occurs almost exclusively in or near pocosins or shrub bogs with dense growths of pines, bays, and various ericaceous shrubs. Individuals are seldom seen except on warm, rainy nights when males can be found calling from perches in vegetation. Insects and other small invertebrates probably constitute the principal food.

Reproduction: Breeding has been reported in small pools, streams, and ditches (Gerhardt 1974), but the reproductive habits in North Carolina are little known. Eggs, larvae, and larval development in New Jersey were described by Noble and Noble (1923), Gosner and Black (1957), and Gosner (1960). The breeding season in the state is probably protracted; choruses have been heard from April through August. Breeding potential in captivity is unknown. Adults kept for several years in a large outdoor pen failed to deposit eggs in the pen pool. The number of North Carolina individuals currently in captivity is unknown but probably few.

Status: *Threatened.* Habitat destruction is the principal threat to this species. Populations are probably stable in undisturbed sections, but considerable development is occurring within the range and this frog is apparently unable to withstand habitat alteration. Because of governmental ownership, habitat might easily be preserved in Bladen Lakes State Forest (Bladen County), Sandhills Wildlife Management Area (Moore, Richmond, and Scotland counties), and Fort Bragg Military Reservation (Cumberland, Hoke, and Moore counties). Population size is unknown. North and South Carolina populations were considered *Threatened* at the Workshop on Threatened and Endangered Vertebrates of the Southeast. Because of their disjunction, all populations are of zoogeographic significance in interpreting the history of the species' evolution and dispersal. In addition, almost all aspects of the life history in the Carolinas remain to be learned. Several workers are investigating the biology of the species.

- References: Conant (1975); see list following introduction.
- Bullard, A. J. 1965. Additional records of the treefrog *Hyla andersoni* from the Coastal Plain of North Carolina. *Herpetologica* 21(2):154-155.
- Gerhardt, H. C. 1974. Behavioral isolation of the tree frogs, *Hyla cinerea* and *Hyla andersonii*. *Amer. Midl. Natur.* 91(2):424-433.
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- _____, and _____. 1967. *Hyla andersonii* Cat. Amer. Amphib. Rept.:54.1-54.2. *Amer. Soc. Ichthyol. Herpetol.*
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Author: William M. Palmer.

REPTILIA; TESTUDINES; EMYDIDAE
(Pond and Marsh Turtles)

Clemmys mühlenbergi (Schoepff)

BOG TURTLE

Description: The Bog Turtle is a small turtle with a bright red, orange, or yellow blotch on each side of the head. The brownish carapace is rough in texture, except in old specimens, and the scutes have yellowish to reddish centers. The plastron is dark brown to black, and may have scattered light markings. Adults range in carapace length from 7.6 to 11.4 cm (3 to 4 1/2 in.). Photographs and a full account are provided by Ernst and Barbour (1972, pp. 76-79 and Plate VI).

Distribution: Range -- discontinuous in E United States from New York to SW North Carolina.

North Carolina -- NW and SW sections of the Blue Ridge Province; localized in upper Piedmont. Recorded from Alleghany, Ashe, Avery, Buncombe, Clay, Forsyth, Henderson, Iredell, Macon, Transylvania, and Watauga cos.

Habitat and Mode of Life: The Bog Turtle inhabits sphagnum bogs and swamps. It also occurs in wet meadows that have thick, grassy cover and are crossed by slow, muddy-bottomed streams. Most of the known habitats in North Carolina are open and sunny. Although bog turtles bask on tussocks of grass and sphagnum, they are generally secretive and burrow rapidly into the mud when disturbed. Their food consists mostly of insects, but also includes earthworms, snails, amphibians, and berries and seeds (pondweed, sedge).

Reproduction: In the northeastern United States mating occurs in May and June, and eggs are laid in June and July. The nesting areas are

located in the bog or marsh habitats. The female may select a site in the moss to deposit eggs, or excavate soil and deposit them below the surface. Usually 3 to 5 eggs are laid. The incubation period is about 50 to 55 days, with hatching occurring in August and September. The eggs and hatchlings are preyed upon by various birds, and mammals including skunks, raccoons, and foxes.

Status: *Threatened*. The Bog Turtle is rare throughout its range, and populations are usually localized and small. Its disjunctive distribution suggests that it was declining long before the European settlement of North America. However, the process has been alarmingly accelerated in recent years because of widespread draining of bogs and marshes. The turtle is also threatened by commercial collecting for the pet trade; individuals reportedly sell for \$150 in the United States and even higher in Europe. In North Carolina, several populations in Nantahala National Forest are being protected by the U. S. Forest Service through maintenance of open bog habitats as sanctuaries. Attempts should be made to protect and maintain habitats of other known populations on private lands through cooperation with landowners. The species is considered *Threatened* by the U. S. Department of the Interior, and was included in this category at the Workshop on Threatened and Endangered Vertebrates of the Southeast. It is listed as *Endangered* and protected by law in Maryland. The Bog Turtle is of zoogeographic interest because of its disjunct distribution.

- References: Barton, A. J., and J. W. Price, Sr. 1955. Our knowledge of the bog turtle, *Clemmys muhlenbergi*, surveyed and augmented. Copeia No.3:159-165.
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Author: Richard C. Bruce.

AMPHIBIA; URODELA; CRYPTOBRANCHIDAE
(Giant Salamanders)

Cryptobranchus alleganiensis alleganiensis (Daudin)

HELLBENDER

Description: The Hellbender is a large aquatic salamander, usually grayish with darker spotting or mottling. Wavy folds of skin along the sides of the body give the animal a wrinkled appearance. The head is flattened and adults lack external gills. Adults range in total length from 29 to 74 cm (11 1/2 to 29 1/8 in.). Photographs and other illustrations are in Bishop (1941), Conant (1975), and Nickerson and Mays (1973), and the latter authors provide a full account of the biology.

Distribution: Range -- S New York through Appalachians to N Georgia, Alabama, and Mississippi, west to Missouri and possibly SE Kansas. A subspecies occurs in parts of SE Missouri and NE Arkansas.

North Carolina -- Blue Ridge Province; on record from French Broad, Hiwassee, Little Tennessee, New, and Watauga drainages. Known from Alleghany, Avery, Buncombe, Cherokee, Clay, Graham, Henderson, Jackson, Madison, Swain, Transylvania, Watauga, and Yancey cos.

Habitat and Mode of Life: Hellbenders inhabit areas of moderate to fast current in large streams and rivers. They use large rocks and logs as shelters and reproduction sites, and are ordinarily nocturnal. They feed primarily on crayfish, but also consume snails, insects, worms, and fish.

Reproduction: Mating and egg-laying occur in August and September. The nests are excavations in the stream bed under large flat rocks or other objects. The male builds the nest and leads the female into it. Following oviposition, the female leaves or is driven away, and the male remains with the eggs until they hatch. The egg mass is in the form of a twisted, rosary-like string. Annual egg production per female is between 300 and 500. Communal nesting is practiced by hellbenders, and such nests may hold nearly 2,000 eggs. Hatching occurs in the fall after an incubation period of 68 to 84 days.

Status: *Special Concern*. The Hellbender is restricted to extreme western North Carolina, and requires clean flowing water. It has undoubtedly been eliminated in many sections of our mountain rivers by pollution and damming. However, maintenance of stream habitats for trout should also enhance survival of the Hellbender. Populations occur in Great Smoky Mountains National Park and in Nantahala and Pisgah National Forests. Bait fishermen occasionally catch hellbenders and usually kill them, but this represents only a minor threat to the species. The Hellbender is one of the largest North American salamanders. The only other members of the family occur in China and Japan.

References: Conant (1975); see list following introduction.
Bishop, S. C. 1941. The Salamanders of New York. N. Y. State Mus. Bull. No. 324, Albany, NY. 365 pages.

- Huheey, J. E., and A. Stupka. 1967. Amphibians and Reptiles of Great Smoky Mountains National Park. Univ. Tennessee Press, Knoxville, TN. 98 pages.
- Nickerson, M. A., and C. E. Mays. 1973. The Hellbenders: North American "Giant Salamanders." Milwaukee Pub. Mus., Publ. Biol. Geol. No. 1, Milwaukee, WI. 106 pages.

Author: Richard C. Bruce.

AMPHIBIA; URODELA; PROTEIDAE
(Waterdogs)

Necturus lewisi Brimley

NEUSE RIVER WATERDOG

Description: A gilled, aquatic salamander, intermediate in size between the allopatric Mudpuppy, *N. maculosus*, and the partially sympatric Dwarf Waterdog, *N. punctatus*. Adults range from 15 to 23 cm (6 to 9 in.) in total length, with a maximum of 27.6 cm (10 7/8 in.). The dorsal color is reddish brown or rusty with large, well-separated blackish spots. The venter is brownish or slate colored and is also spotted. The genus is characterized by large external gills and two pairs of well-developed, four-toed legs. Illustrations are in Bishop (1943), Conant (1975, p. 244), and Fedak (1971).

Distribution: Range -- North Carolina endemic; Coastal Plain and lower Piedmont of Neuse and Tar River systems. Museum specimens from Beaufort, Craven, Durham, Franklin, Greene, Nash, Orange, and Wake cos. Literature records from Edgecombe, Lenoir, and Pitt cos. are not verified but probably valid.

Habitat and Mode of Life: The Neuse River Waterdog occurs in temporary and permanent leaf beds in backwaters and quiet parts of larger streams and rivers. It is most common along the Fall Line and the lower Piedmont, and less often collected in the Coastal Plain. Most are taken from December to March, and it is rarely found during warmer months. Fedak (1971) considered it a general feeder on the vertebrate and invertebrate fauna of the leaf beds.

Reproduction: Nothing is known of courtship, mating, nests, or nesting behavior. Based on examination of captured adults, breeding occurs during the winter with eggs laid in late spring and hatching in late summer (Fedak 1971). From 17 to 75 yolked oocytes have been found in dissected adults. Sexual maturity is reached 5.5 to 6.5 years after hatching.

Status: *Special Concern.* Its limited, endemic distribution makes this salamander especially vulnerable to industrial and agricultural pollution. Habitat modification, like damming, dredging or

channelization, would doubtless have an adverse effect. Present population size and trends are unknown. The Neuse River Waterdog was considered a species of *Special Concern* at the Workshop on Threatened and Endangered Vertebrates of the Southeast. The species is of interest because of its restricted distribution and uncertain position within the genus. Very little is known about most aspects of its natural history, and there is much to be learned of its role in the evolution and systematics of proteid salamanders.

References: Conant (1975); see list following introduction.
Bishop, S. C. 1943. Handbook of Salamanders. Comstock Publ. Co., Ithaca, NY. 555 pages.
Fedak, M. A. 1971. A comparative study of the life histories of *Necturus lewisi* Brimley and *Necturus punctatus* Gibbs (Caudata: Proteidae) in North Carolina. Unpub. MA thesis, Duke Univ., Durham, NC. 103 pages.

Author: David L. Stephan.

AMPHIBIA; URODELA; AMBYSTOMATIDAE
(Mole Salamanders)

Ambystoma talpoideum (Holbrook)

MOLE SALAMANDER

Description: The Mole Salamander is characterized by a stout body, a disproportionately large head, and a tail slightly shorter than the body. Its color is brownish gray to steel gray, with whitish or bluish flecks scattered throughout. Adults range from 46 to 68 mm (1 3/4 to 2 5/8 in.) in snout-vent length, and 81 to 122 mm (3 1/8 to 4 3/4 in.) total length. Costal grooves number 10 or 11. The larvae have large dark blotches on the body and tail, smaller dark blotches on the tail fins, and usually a dark midventral stripe. For additional information and illustrations see Conant (1975, p. 251 and Plate 38).

Distribution: Range -- Coastal Plain from South Carolina through Georgia and N Florida to extr. E Texas; up Mississippi Basin to SE Oklahoma and S Illinois. Other populations in N-central Tennessee, NE Alabama, extr. E Tennessee, and W North Carolina.

North Carolina -- French Broad, Little Tennessee, and Hiwassee River drainages. Museum specimens from Buncombe, Cherokee, Henderson, and Macon cos. Literature record for Transylvania Co. (Bishop 1943) probably valid.

Habitat and Mode of Life: Adults of this salamander are found in floodplains or flatwoods where ponds suitable for breeding occur. Terrestrial adults are burrowers and are difficult to find except when they emerge for breeding. Food consists largely of insects and earthworms.

Reproduction: The reproductive habits of the Mole Salamander are essentially unknown in North Carolina. Breeding probably occurs during December, January, or February, as in other parts of the range. The breeding period is reportedly associated with rain and relatively cold temperatures, lasting from a few days to about two weeks. Fourteen females collected prior to breeding in Louisiana contained from 226 to 401 eggs (Shoop 1960). The number of North Carolina specimens in captivity is unknown, and captive breeding potential is probably good.

Status: *Special Concern*. Mole Salamander populations in North Carolina appear to be disjunct and are probably relicts from a time when the species was more widespread. Their distribution is not well known, and unusual aspects of their biology make them very important from a taxonomic and natural history viewpoint. Breeding sites are rare in the mountain valleys of this state, and disturbance of the few known localities could seriously threaten the existence of this salamander here.

References: Conant (1975); see list following introduction.
Bishop, S. C. 1943. Handbook of Salamanders. Comstock Publ. Co., Ithaca, NY. 555 pages.
Mount, R. H. 1975. The Reptiles and Amphibians of Alabama. Agri. Exp. Sta., Auburn Univ., Auburn, AL. 347 pages.
Shoop, R. C. 1960. The breeding habits of the mole salamander, *Ambystoma talpoideum* (Holbrook), in southeastern Louisiana. Tulane Stud. Zool. 8(3):65-82.
_____. 1964. *Ambystoma talpoideum*. Cat. Amer. Amphib. Rept.:8.1-8.2. Amer. Soc. Ichthyol. Herpetol.
Smith, P. W. 1961. The Amphibians and Reptiles of Illinois. Bull. Ill. Nat. Hist. Surv. 28(1):1-298.

Author: Alvin L. Braswell.

AMPHIBIA; URODELA; PLETHODONTIDAE
(Lungless Salamanders)

Aneides aeneus (Cope and Packard)

GREEN SALAMANDER

Description: This is a distinctive salamander that shows a pronounced flattening of the body. The dark upper surfaces are marked with green or yellowish green lichenlike patches. The long toes have expanded tips. Adults range in total length from 8 to 14 cm (3 1/4 to 5 1/2 in.). The species is not easily confused with other species of salamanders in the state. A color illustration is in Conant (1975, Plate 43).

Distribution: Range -- Blue Ridge Mountains in Carolinas and Georgia; Allegheny and Cumberland Mountains, and adjacent areas, SW Pennsylvania to central Alabama.

North Carolina -- SW Blue Ridge Mountains in Bat Cave area (Henderson, Rutherford cos.), and Blue Ridge escarpment (Jackson, Macon, Transylvania cos.). Possibly in Great Smoky Mountains.

Habitat and Mode of Life: The Green Salamander usually inhabits damp crevices of rock outcrops, cliffs, and ledges. It also lives under the bark of standing trees and fallen trunks. Its food includes insects and other invertebrates.

Reproduction: The life history and reproductive habits have been studied in detail (Gordon 1952). Females deposit eggs in narrow rock crevices in June, and remain with the eggs until hatching, some 84 to 91 days later. The number of eggs per clutch ranges from 10 to 26 (average 17), and a single clutch is deposited per female per year.

Status: *Special Concern*. The very restricted range in North Carolina, as well as the localization and small sizes of the populations within this range, justify inclusion of the Green Salamander in this category. Some populations in the Blue Ridge escarpment gorges in South Carolina have been extirpated by impoundment of the Keowee River, and nearby populations in North Carolina will be eliminated by further damming of the escarpment tributaries of the Keowee. Collecting by amateur and professional herpetologists has seriously depleted some populations. However, many colonies are located on sheer rock cliffs that are ordinarily inaccessible to humans. Populations occur on National Forest lands (Nantahala and Pisgah), including the Chattooga National Wild and Scenic River Unit. The Green Salamander is of zoogeographic interest inasmuch as the genus *Aneides* has a discontinuous distribution, with four species in western North America and only *A. aeneus* in the East. The Green Salamander has been afforded the status *Endangered* in Mississippi and Maryland, and is protected by law in the latter state. In South Carolina it is tentatively treated as a *Threatened* peripheral species, and is *Rare* or *Unusual* in Georgia. Tennessee's tentative list treats it as a species of *Special Concern*.

References: Conant (1975); see list following introduction.

Bruce, R. C. 1968. The role of the Blue Ridge Embayment in the zoogeography of the green salamander, *Aneides aeneus*. *Herpetologica* 24:185-194.

Gordon, R. E. 1952. A contribution to the life history and ecology of the plethodontid salamander *Aneides aeneus* (Cope and Packard). *Amer. Midl. Natur.* 47:666-701.

_____. 1961. The movement of displaced green salamanders. *Ecology* 42:200-202.

_____. 1967. *Aneides aeneus*. *Cat. Amer. Amphib. Rept.*:30.1-30.2. *Amer. Soc. Ichthyol. Herpetol.*

Author: Richard C. Bruce.

Eurycea longicauda longicauda (Green)

LONG-TAILED SALAMANDER

Description: A yellow to orange salamander, with black spots on the trunk and vertical black markings on the tail. The tail is long, comprising more than half the total length. Adults range from 10 to 19.7 cm (4 to 7 3/4 in.) in total length. A color illustration is in Conant (1975, Plate 43).

Distribution: Range -- S New York, southwestward to NW Georgia, west to Missouri.

North Carolina -- extreme W mountains, including Alleghany, Graham, Haywood, Macon, and Watauga cos.

Habitat and Mode of Life: This species is found near the margins of streams and ponds, and lives under logs, stones, and other debris. In some parts of its range it frequents caves. In North Carolina it occurs primarily in floodplains along larger streams, and uses small ponds in these habitats for breeding. Food consists of small invertebrates.

Reproduction: Females deposit eggs in autumn or winter in secluded sites in the banks of streams or ponds, or in pools in caves. The number of eggs per clutch ranges from 61 to 106, and it is likely that females produce one clutch a year. The eggs hatch in late winter, and the aquatic larvae metamorphose three to four months later. Maturity is attained at 45 to 50 mm (1 3/4 to 2 in.) snout-vent length and at an age of about three years.

Status: *Special Concern*. The Long-tailed Salamander is common throughout much of its range, but is of concern here because of its very restricted distribution in the state. Known populations are small and localized. Furthermore, the North Carolina populations have scientific value in the study of the relationships between this form and the Three-lined salamander, *E. l. guttolineata*. The latter is distributed statewide, but either intergrades with the Long-tailed or is replaced by it where the ranges of the two meet along the North Carolina-Tennessee border. Thus, these salamanders act as subspecies in some areas of contact, but as full species elsewhere. This problem is still under investigation by several herpetologists.

References: Conant (1975), Huheey and Stupka (1967); see list following introduction.

Anderson, J. D., and P. J. Martino. 1966. The life history of *Eurycea longicauda longicauda* associated with ponds. Amer. Midl. Natur. 75: 257-279.

Bailey, J. R. 1937. Notes on plethodont salamanders of the southeastern United States. Occas. Pap. Mus. Zool. Univ. Mich. 364:1-10.

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Valentine, B. D. 1962. Intergrading populations and distribution of the salamander *Eurycea longicauda* in the Gulf States. J. Ohio Herpetol. Soc. 3:42-51.

Author: Richard C. Bruce.

Plethodon welleri Walker

WELLER'S SALAMANDER

Description: This small, slender salamander is black, with many brassy, copper, or golden blotches that may cover more than 70% of the dorsum. These markings are its most diagnostic feature. The venter is plain black or may be spotted with white. The tail is round, slender, and tapered. The toes are slender and partially webbed. Males have circular mental glands on the ventral surface of the lower jaw; these reach greatest development in the fall. Their lower jaw is more pointed than that of females, and the ends of their nasolabial grooves are enlarged. Adults are 64 to 79 mm (2 1/2 to 3 1/8 in.) in total length. A color photograph is in Conant (1975, Plate 40).

Distribution: Range -- a few localities in S Blue Ridge Province: NW North Carolina, extr. NE Tennessee, and Mount Rogers and Whitetop Mountain SW Virginia.

North Carolina -- known only from Grandfather Mountain (type locality), Avery Co., and a few sites along Tennessee border near Flat Top Mountain, Yancey Co.

Habitat and Mode of Life: This salamander occurs mainly above 1,500 m (5,000 ft.) but has been reported from 750 m (2,500 ft.) in Johnson County, Tennessee. It is an inhabitant of forested areas occupied by Hemlock, *Tsuga canadensis*; Red Spruce, *Picea rubens*; Yellow Birch, *Betula alleghaniensis*; and Great Laurel, *Rhododendron maximum*. Most specimens are found under rocks and logs. Small worms and insects are the main foods.

Reproduction: The reproductive season is short. In late July or early August clutches of 4 to 11 eggs are laid in well rotted conifer logs under a thick mat of moss. Hatching occurs in late August and individuals become sexually mature when a snout-vent length of 35 mm (1 3/8 in.) is reached. Courtship takes place in October.

Status: *Special Concern.* Weller's Salamander probably represents a near casualty of the last glaciation (about 10,000 years ago), which caused extensive extinctions among the many species then in the southern mountains. The greatest concentrations of this salamander now occur near the summits of high mountains, but even in such optimum habitats only sparse numbers have been found. There are only a few hundred specimens in the major museums of the United States. The small numbers of this highly isolated, relict species warrant careful consideration. Its survival is closely dependent on an undisturbed, stable, and cool environment.

Remarks: Some authorities recognize two subspecies: *P. w. welleri* of Grandfather Mountain, and *P. w. ventromaculatum* elsewhere.

- References: Conant (1975); see list following introduction.
- Bishop, S. C. 1943. Handbook of Salamanders. Comstock Publ. Co., Ithaca, NY. 555 pages.
- Highton, R. 1962. Revision of North American salamanders of the genus *Plethodon*. Bull. Fla. State Mus. 6:235-367.
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- Organ, J. A. 1960. Studies on the life history of the salamander, *Plethodon welleri*. Copeia No. 4:287-297.
- Snyder, R. C. 1946. *Plethodon welleri* from Flat Top Mountain, North Carolina. Copeia No. 3:174.
- Thurrow, G. R. 1956. A new subspecies of *Plethodon welleri*, with notes on other members of the genus. Amer. Midl. Natur. 55:343-356.
- _____. 1963. Taxonomic and ecological notes on the salamander, *Plethodon welleri*. Univ. Kansas Sci. Bull. 44:87-108.
- _____. 1964. *Plethodon welleri* Walker. Cat. Amer. Amphib. Rept.: 12.1-12.2. Amer. Soc. Ichthyol. Herpetol.

Author: Bernard S. Martof.

AMPHIBIA; ANURA; RANIDAE
(True Frogs)

Rana areolata capito Le Conte

CAROLINA GOPHER FROG

Description: This is a medium-sized and very distinctive frog. It is gray in color, with dark, somewhat obscured spots, exceptionally warty skin, and a disproportionately large head. The venter is variously spotted or mottled with dark pigment. Although it is very warty, the presence of dorsolateral ridges separates the Gopher Frog from toads. It ranges in size from 64 to 89 mm (2 1/2 to 3 1/2 in.) in snout-vent length. A more detailed description and illustrations of other gopher frogs are found in Conant (1975, p. 349 and Plate 48).

Distribution: Range -- Coastal Plain from E-central North Carolina to E Louisiana. Two other subspecies from central Mississippi north to SW Indiana and S Iowa, south to Gulf of Mexico in Texas and Louisiana.

North Carolina -- restricted to Coastal Plain from Beaufort Co. south. Museum specimens from Beaufort, Bladen, Brunswick, Carteret, New Hanover, Jones, and Scotland cos.

Habitat and Mode of Life: This is a frog of upland, sandy ridges with pine, wire grass, and turkey oak, and temporary or permanent ponds for breeding. Adults visit the ponds during breeding season, but the

rest of the year is spent away from water, presumably in burrows of rodents, crayfish, or other small animals. Food consists of almost any animal small enough to be swallowed.

Reproduction: Little is known of the breeding in North Carolina, but it normally occurs in late winter or early spring. The call of the male in a breeding chorus is a deep snore that can be heard for long distances. The number of eggs per clutch has been estimated at 7,000 in Kansas and 5,000 in Illinois. No known North Carolina specimens are in captivity and captive breeding potential is unknown.

Status: *Special Concern.* The Carolina Gopher Frog is secretive and can usually be found only during the breeding season. Thus, data on life history and population size are difficult to obtain. It was considered *Threatened* by the Workshop on Threatened and Endangered Vertebrates of the Southeast, and when more is known about the form in North Carolina it may well be found to deserve this status here. Habitat destruction is by far its greatest danger. The upland, sandy ridges which it requires are prize sites for commercial and residential development in many areas. Such development is occurring at a rapid rate in New Hanover and Brunswick counties.

- References: Conant (1975); see list following introduction.
Goin, C. J., and M. G. Netting. 1940. A new gopher frog from the Gulf Coast, with comments upon the *Rana areolata* group. *Ann. Carnegie Mus.* 28:137-168.
Minton, S. A., Jr. 1972. Amphibians and Reptiles of Indiana. *Ind. Acad. Sci., Monogr.* 3, Indianapolis, IN. 346 pages.
Palmer, W. M., A. L. Braswell, and D. L. Stephan. 1974. Noteworthy herpetological records from North Carolina. *Bull. Md. Herpetol. Soc.* 10(3):81-87.
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Wright, A. H. 1932. Life-histories of the frogs of Okefinokee Swamp, Georgia. Macmillan Co., N. Y., NY. 497 pages.
_____, and A. A. Wright. 1949. Handbook of Frogs and Toads of the United States and Canada. Comstock Publ. Assoc., Ithaca, NY. 640 pages.

Author: Alvin L. Braswell.

REPTILIA; SQUAMATA; SCINCIDAE
(Skinks)

Eumeces anthracinus (Baird)

COAL SKINK

Description: The Coal Skink has smooth, shiny scales and four light lines on the body. Striped individuals of other species of the genus in North Carolina have five light body lines. The Coal Skink also has a broad black or dark brown lateral stripe, bordered on both sides by a narrow light line. The Ground Skink has a dark lateral stripe, too, but it is not bordered by light lines. The back of the Coal Skink is olive brown to brown, sometimes with a brassy appearance. Young are like the adults but have blue tails. Adults range to 67 mm (2 3/8 in.) in snout-vent length, and 130 to 178 mm (5 to 7 in.) total length. Additional descriptive material and a color illustration can be found in Conant (1975, pp. 126-127 and Plate 19).

Distribution: Range -- discontinuous from New York down the Appalachians to Virginia, Kentucky, and Alabama. A southern subspecies occurs in Georgia, Florida panhandle, Alabama, E Texas, Missouri, and Kansas, and intergrades with the northern form in parts of the southeast.

North Carolina -- SW mountains, excluding the Great Smokies. Museum specimens from Buncombe, Henderson, Haywood, Jackson, Macon, and Transylvania cos.

Habitat and Mode of Life: The Coal Skink prefers moist, humid areas, usually in the vicinity of water. It is normally found under rocks, logs, or leaf litter. In the Appalachians it occurs in the forest type formerly dominated by chestnut, chestnut oak, and yellow poplar. Its food consists primarily of small insects and spiders.

Reproduction: Nothing is known of the breeding habits of this skink in North Carolina. Elsewhere, coal skinks breed in the spring and lay their eggs in May or June. Clutch sizes range from four to nine and the female remains with the eggs until hatching, which occurs in four or five weeks. Hatchlings range from about 47 to 51 mm (1 7/8 to 2 in.) total length. No known North Carolina coal skinks are in captivity. One report of a successful captive breeding has been reported.

Status: *Special Concern.* In North Carolina the Coal Skink has low population densities, and occupies a restricted range and a strategic location in an area of intergradation between two subspecies. Because of its low population densities, secretive habits, and difficulty in obtaining specimens, little is known of it in this state. This lack of knowledge makes it very important from a taxonomic and life history viewpoint. It is of concern in other states, including Maryland, where it is considered *Endangered*, and Georgia, where it is classed as *Rare or Unusual*. The southern subspecies, *E. a. pluvialis*, is considered *Endangered* in Mississippi.

- References: Conant (1975); see list following introduction.
- Anderson, P. 1965. The Reptiles of Missouri. Univ. Missouri Press, Columbia, MO. 330 pages.
- Dowling, H. G. 1950. A new southeastern record for the coal skink. Copeia No.3:235.
- Mount, R. H. 1975. The Reptiles and Amphibians of Alabama. Agri. Exp. Sta., Auburn Univ., Auburn, AL. 347 pages.
- Smith, H. M. 1946. Handbook of Lizards. Comstock Publ. Co., Ithaca, NY. 557 pages.
- Smith, P. W., and H. M. Smith. 1952. Geographic variation in the lizard *Eumeces anthracinus*. Univ. Kansas Sci. Bull. 11:679-694.

Author: Alvin L. Braswell.

REPTILIA; SQUAMATA; COLUBRIDAE
(Colubrid Snakes)

Lampropeltis getulus sticticeps Barbour and Engels

OUTER BANKS
KINGSNAKE

Description: This kingsnake is black or brown with 22 to 33 bands, as in the Eastern Kingsnake, and often has light spots on the dorsal scales of the interspaces. The snout tapers acutely due to the enlarged rostral scale. For a complete description and illustrations see Barbour and Engels (1942) and Lazell and Musick (1973).

Distribution: Range — North Carolina endemic. Outer Banks from Cape Hatteras to Cape Lookout (Core Banks, Ocracoke Island and SW arm Hatteras Island), including parts of Carteret, Dare, and Hyde cos.

Habitat and Mode of Life: According to Lazell and Musick (1973) this snake is restricted to the intra-Capes ecological zone, characterized by the abundance of Scrub Palmetto, *Sabal minor*, and Cactus, *Opuntia drummondii*, and the corresponding absence of Flowering Dogwood, *Cornus florida*, and American Hornbeam, *Carpinus caroliniana*. Other species ratios in the communities also differ. The vegetation structure from Buxton Woods northward and from Shackelford Banks westward more closely resembles that of the mainland and is reportedly occupied by the Eastern Kingsnake, *L. g. getulus*. The floral associations of the intra-Capes zone, and the factors influencing them, thus appear to be critical to the fossorial Outer Banks Kingsnake.

Reproduction: Nothing is known about reproduction in this form. In their report to the Workshop on Threatened and Endangered Vertebrates of the Southeast, R. M. Blaney and W. M. Palmer suggested that 4 to 10 eggs are probably laid annually. Wright and Wright (1957) indicated 5 to 24 eggs for the Eastern Kingsnake.

Status: *Special Concern.* The size of the present population and changes from the past are unknown. Most of the range of this snake occurs within the Cape Hatteras National Seashore, which protects it from the hazards of development. In its fragile and restricted habitat, however, it remains highly vulnerable to natural disasters like storms, changes in the Outer Banks with shifting currents, genetic swamping from adjacent populations, etc., and also to collectors and wanton killing. This form is particularly interesting because virtually nothing is known of its natural history and role in the ecology of the intra-Capes zone. Its systematic status, whether a valid taxon or an ecotype adapted to the Outer Banks, is still open to question, as are other aspects of its biology. This kingsnake is not the only problematical form associated with the Outer Banks, and the zoogeographical and evolutionary significance of these organisms calls for additional study.

References: Barbour, T. R., and W. L. Engels. 1942. Two interesting new snakes. Proc. New England Zool. Club 20:101-104.
Lazell, J. D., Jr., and J. A. Musick. 1973. The kingsnake, *Lampropeltis getulus sticticeps*, and the ecology of the Outer Banks of North Carolina. Copeia No.3:497-503.
Wright, A. H., and A. A. Wright. 1957. Handbook of Snakes of the United States and Canada. Comstock Publ. Assoc., Ithaca, NY. 564 pages.

Author: David L. Stephan.

REPTILIA; SQUAMATA; ELAPIDAE
(Elapid Snakes)

Micrurus fulvius fulvius (Linnaeus)

EASTERN CORAL SNAKE

Description: This is a moderately slender, highly venomous snake with a black snout and bright bands of red, yellow, and black encircling the body. The red bands are variously speckled with black and touch the yellow bands. Adults in North Carolina range in total length from about 46 to 76 cm (18 to 30 in.). Similar species are the harmless Scarlet Snake, *Cemophora coccinea*, and Scarlet Kingsnake, *Lampropeltis triangulum elapsoides*, both of which have red snouts and touching red and black patterns. Scarlet snakes also have essentially unmarked undersurfaces. Photographs and accounts are provided by Palmer (1974), and Wright and Wright (1957). A color plate comparing this snake with the harmless species is in Conant (1975, Plate 30).

Distribution: Range — SE North Carolina south to Florida and Key Largo, west to W-central Mississippi and extr. E Louisiana. A western subspecies occurs from S Arkansas and Louisiana to W-central Texas, south into Mexico.

North Carolina -- S Coastal Plain and Sandhills. Museum specimens from Bladen, Brunswick, Cumberland, Harnett, Hoke, Moore, New Hanover, and Scotland cos. Literature records (not supported by specimens but probably valid) from Onslow and Pender cos. Former distribution in the state not known; possibly included more xeric parts of longleaf pine forests which covered much of Coastal Plain before extensive lumbering and turpentine operations.

Habitat and Mode of Life: The Coral Snake is virtually restricted to sandhills of pines and various scrub oaks, dry pine flatwoods, and sandy maritime forests. This secretive snake apparently spends much time underground or buried in ground litter. Surface activity occurs most often in the morning. Small snakes and lizards are the major food.

Reproduction: Nothing is known about reproduction in North Carolina. Summarizing the scanty literature, Fitch (1970) recorded clutches of seven, seven, and nine eggs. Presumably most matings take place in the spring. Eggs are laid in late spring or early summer and hatch probably in August and September. Hatchlings are 18 to 23 cm (7 to 9 in.) in total length (Conant 1975). Breeding potential in captivity is unknown but probably poor, and most captives survive only for short periods. Few, if any, North Carolina individuals are in captivity.

Status: *Special Concern.* The Coral Snake in North Carolina is apparently very rare. Only about 20 specimens are available in museums (Palmer 1974). Habitat might easily be preserved on governmental lands such as Bladen Lakes State Forest (Bladen County), Sandhills Wildlife Management Area (Moore, Richmond, and Scotland counties), and Fort Bragg Military Reservation (Cumberland, Hoke, and Moore counties). Most recent records, however, are from areas in Brunswick and New Hanover counties where habitat is being rapidly altered or destroyed by industrial and commercial development. Population size is unknown but is probably so small as to prevent a systematic study of life history. This species in North Carolina is of considerable scientific interest because so little is known about it. Furthermore, the populations are peripheral and therefore of evolutionary and taxonomic significance. The Coral Snake is considered *Rare* in Georgia, and tentatively *Threatened* in South Carolina.

Remarks: Coral snakes have highly toxic venom and deaths from their bites are a matter of record. However, their fangs are short and many bites, especially those inflicted against even the lightest clothing, seem ineffective. Because these snakes are rarely encountered, and because they usually bite only when restrained, they pose a lesser danger to humans than do other venomous snakes.

References: Brimley (1939-43), Conant (1975), Palmer (1974); see list following introduction.
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Author: William M. Palmer.

Species of Status Undetermined

The Eastern Tiger Salamander, *Ambystoma t. tigrinum*; Four-toed Salamander, *Hemidactylium scutatum*; Zigzag Salamander, *Plethodon d. dorsalis*; Wehrle's Salamander, *Plethodon wehrlei*; Mudpuppy, *Necturus m. maculosus*; Mountain Chorus Frog, *Pseudacris brachyphona*; Eastern Spiny Softshell, *Trionyx s. spiniferus*; Carolina Salt Marsh Snake, *Natrix sipedon williamengelsi*; and Eastern Smooth Green Snake, *Opheodrys v. vernalis*, are all of concern in North Carolina. Because of a paucity of data, however, they cannot be precisely assigned to any category, and are considered to be of status *Undetermined*. Research is in progress on the natural history of several of these animals, but a great deal more field work will be required before their condition can be assessed with any accuracy.

Editor's Note: Since this report was completed, Sever, Dundee and Sullivan (1976 *Herpetologica* 32(1):26-29) described a new plethodontid salamander, *Eurycea junaluska*, from the Cheoah River valley of Graham County. The species was described on the basis of 23 specimens, and its apparent rarity and localization make it of some concern. It is probably best assigned to the *Undetermined* category until further studies of its distribution and requirements are made.

In addition, Highton and Webster (1976 *Evolution* 30:33-45) elevated *Plethodon cinereus serratus* to species status, and indicated that extreme southeastern Tennessee and adjacent North Carolina fall within the range of an isolate of this form. It is not considered to be of particular concern at this time.

These species raise the number of salamanders in the state list to 41, and the total number of species to 139. They also point up the fact that even basic taxonomic work on the North Carolina herpetofauna is not yet complete.

Birds

Introduction
by
James F. Parnell

One of the things I learned from Dr. Hardin's presentation at the Symposium is that ornithologists and botanists have a whole lot more in common than I thought. His generalizations apply to birds as well as plants, and many of his comments were very appropriate to the discussion at this point. There is one major exception. When looking at the *Threatened* and *Endangered* species of birds in North Carolina, we find that none are endemic to this state.

There are two possible ways in which birds may be considered *Endangered* in North Carolina. They may be considered of this status over their entire ranges, including a part or all of the state, or they may be in danger only in North Carolina and more common or abundant elsewhere. We have looked at both of these situations, and I will comment on each later.

The Bird Committee was a rather sizeable one, and its members worked diligently to put this list together. I am very grateful for their work. It was an interesting committee. Those of us who work with birds have an advantage over most of the other groups in that there are a large number of what we often call "amateur" bird watchers throughout the state. These are the people who really know where the birds are and their status. We also have a group of professional people involved who may make their livings working with birds but often don't know nearly as much as the "amateurs". We put together a combination of those groups, and what we are recommending represents a very good cross-section of opinion about the bird situation in North Carolina.

Birds, of course, move about a great deal, so a bird record for a given area does not have quite the same weight as a record for some less mobile organism. This makes the evaluation of bird populations somewhat more difficult, and what we are presenting here is expert opinion, often based on considerable periods of time spent in the field, but not very often based on precise scientific studies. The thing that needs stating most forcefully is that we need a whole lot more field work. We have only scratched the surface and are making suggestions. We hope this will generate lots of enthusiasm and interest, and we also hope that many people will get into the field and try to verify present opinions. We further hope that in the very near future there will be an opportunity to re-evaluate this list in the light of new opinions and more hard data.

There is good documentation that several species of extinct birds once occurred in North Carolina. Others are known to be extirpated, at least as breeding species. According to Colonel William Byrd, the Carolina Paroquet was common when he surveyed the North Carolina-Virginia boundary line in 1728. There are no state records after this, but the species is known to have survived in South Carolina and Tennessee well into the second half of the 19th century. Passenger pigeons once migrated through the mountains and Piedmont of North Carolina in large numbers. They were apparently still common through the early 1870's, but their decline was rapid and the last record for the state was in 1894.

Alexander Wilson collected a specimen of the rare Ivory-billed woodpecker 12 miles north of Wilmington, North Carolina, about 1800. Although Audubon reported this bird from as far north as Maryland, the Wilmington locality probably represents the northern limit of its historic range. There are no other records for the state, although the species was known to occur in the Santee River swamp of South Carolina, 70 miles from the North Carolina line, well into the 20th century.

No authentic records for either the Great auk or the Eskimo curlew have been made for North Carolina. Evidence indicates, however, that the Auk regularly wintered as far south as Florida, and numerous fossil Auk bones have been found at the Lee Creek Mine, Beaufort County. The Eskimo curlew was apparently an off-shore migrant which almost certainly flew regularly over North Carolina coastal waters.

The rare and elusive Bachman's warbler, a bird considered *Endangered* in the federal listings, was found on one occasion in North Carolina, at Raleigh in 1891. It was reported from South Carolina in 1976. Kirtland's warbler, also a federal *Endangered* species, is an occasional migrant through the state. Both of these migratory warblers are in serious trouble because of massive habitat changes in their wintering quarters in Cuba and the Bahamas, and certain deleterious factors operating in their summer habitats in this country. Other birds that have probably been extirpated from North Carolina, at least as breeding species, are discussed in individual species accounts which follow.

We have listed four species of birds as *Endangered* in North Carolina: the Brown pelican, Bald eagle, Peregrine falcon, and Red-cockaded woodpecker. These species are on the federal list and considered *Endangered* throughout their ranges in North America. Abundances of these species vary a good deal within North Carolina. The Bald eagle is seen only occasionally and apparently no longer nests in this state. The Red-cockaded woodpecker, although present in fairly substantial numbers, is nevertheless considered to be *Endangered* throughout its range. In calling a bird species *Endangered* we have attempted to stay with those where the hazard is pretty clear. These are cases where we know the factors leading to the endangerment, and where we can generally see the causative actions. In some cases we can almost see the end of the line for the species.

The *Threatened* category represents those birds for which the people who know about them in North Carolina are very much concerned, but where the evidence of endangerment is often not nearly so clear. We really think that a number of those listed as *Threatened* are actually *Endangered*, and with better data these species may be elevated to the latter status in a few years. The *Threatened* forms fall generally into two categories. There are a number of birds that occur in all or part of North Carolina and are known to be declining throughout their ranges. Data on these species are relatively good on a long-term basis, showing gradual decline. There are other birds in this category which are peripheral, reaching the southern limits of distribution in our mountains and confined to rather specialized habitats. Their problems are problems of habitat, and opinion here is not as clear as it is in the first situation. There is a difference of opinion, for example, as to whether or not the spruce-fir habitat is in danger. If this habitat is endangered on the high mountain peaks in western North Carolina, then certainly the birds that nest only there are also in trouble. This is not a very large group. The Double-crested

cormorant, Anhinga, Least bittern, Turkey vulture, Black vulture, Sharp-shinned hawk, Cooper's hawk, Red-shouldered hawk, Golden eagle, Merlin, and American kestrel -- these are all birds probably undergoing population declines throughout their ranges. They may exist over relatively wide parts of North Carolina, like the Turkey and Black vultures, and Red-shouldered hawk, or they may be very much restricted in the state, as are the Double-crested cormorant and Anhinga.

We are generally, although not always, speaking of breeding populations. The plant folks don't have too much trouble about things migrating into and out of the state, but with birds, of course, we have a great influx every fall. There is a wintering community consisting of many species that do not nest here, that move back to more northern nesting areas in the summer. So, for example, we are very concerned about the Black-capped chickadee in North Carolina, which only nests on a few mountain peaks. To the north there are lots of Black-capped chickadees, but they do not generally migrate into our state in large numbers. The Brown creeper nests on some of the same mountain peaks, and we are equally concerned about its nesting population. It is a fairly common winter resident throughout the state, but only a small population nests within our confines. This group of more restricted species includes the Saw-whet owl, Olive-sided flycatcher, Black-capped chickadee, Brown creeper, Bewick's wren, Warbling vireo, Cerulean warbler, and Bachman's sparrow. Several of these are restricted to mountain peaks, others are restricted to small units of habitat in the Coastal Plain, and some are generally widespread through the state. These are all of concern, for a variety of reasons. With further work we fully expect to find that some are more abundant than present evidence indicates, and we may wish in the relatively near future to relegate them to a category of less concern. On the other hand, we may discover that some are *Endangered*. We hope this group will receive particular study and attention over the next several years.

There is also a fairly large group of birds which we consider to be of *Special Concern*, but which don't seem to be in danger of immediate extirpation. They fall into two general categories. The first is a group of species which exist in limited habitats or small units of habitat, or seem to show a general decline over a broader range. There are 11 species in this group, including the Red-tailed hawk, Turkey, Barn owl, Red-headed woodpecker, Common raven, and Loggerhead shrike. The second group consists of 28 species of concern because there is some facet of their biology that makes them particularly susceptible to the kinds of changes that we are seeing in the habitats of North Carolina relative to man's current activities. All of the wading birds are in this category. They nest in mixed species colonies of a few hundred to several thousand pairs, generally on small isolated islands in the estuary, and are present in relatively good numbers. Some populations we know to be increasing. But, we also know that a moment of carelessness in the estuary, like dumping dredge spoil on the wrong place at the wrong time, could destroy a significant portion of the breeding effort for a number of these species. A case in point is the White ibis. There are probably between 2,000 and 3,000 nesting pairs on the North Carolina coast, and their numbers are increasing each year. But, 99% of them nest on Battery Island just off Southport. Were we to have a problem at Battery Island, White ibises

could go from rather abundant to rare and *Endangered* almost overnight.

The same kind of thing can be said for the nesting gulls and terns along the coast. They also nest primarily on low coastal islands, and are dependent on a small amount of nesting habitat. The numbers of several species are rather large at present and, in a few cases, populations appear to be increasing. Numbers of Least terns and Gull-billed terns are low, however, and the status of both was considered borderline between this category and *Threatened*. Habitat for gulls and terns is actually being constructed, mainly by the Corps of Engineers, but with changes in coastal politics and policies this could be gone in 20 years. We must be particularly concerned about these species, although most are presently doing well, because our own activities are so important in maintaining their populations.

There are a number of other species that do not fit this general situation. There seems to be evidence that Black ducks are accumulating pesticides somewhat the same as raptors have in past years, and there may be problems here. There are a few birds, like the King rail, Purple gallinule, and Common gallinule, which nest primarily in small, freshwater marshes of the Coastal Plain and eastern edge of the Piedmont. This habitat is gradually declining. Small freshwater marshes are continually being drained, and freshwater lakes are being deepened and marshes eliminated from their edges.

We are concerned, then, about a good many species. We frankly do not know in many cases what is happening to populations, but we see habitat declining and assume that the birds must be going also. We need not mention other examples of this sort. The species' accounts will give our reasoning for the status of each species, and these can be evaluated more carefully by the reader. There are 18 other species that we consider of *Undetermined* status. These are birds for which data are so scarce that the Committee was unable to form any other opinion. They include species like the Swallow-tail kite, for which records in North Carolina are extremely sporadic and without real pattern, and for which we simply could not arrive at a consensus. We are relatively sure that with further work some of these species will fit into other categories, and others may drop from the area of concern.

All species listed need considerably more work and better data for really positive evaluations of their status, but it's quite clear that there are problems. Over the next several years this report should evolve into one that will represent careful study in all cases and precise scientific opinion on these species.

All scientific and common names used in lists and accounts are from the 1957 AOU "Check-list of North American Birds," Fifth Edition, brought up to date from the literature. Several general references are listed below, and more specific references are provided following each of the major species accounts.

References

- Forbush, E. H. 1955. A Natural History of American Birds of Eastern and Central North America. Revised and abridged by J. B. May. Bramhall House, N. Y., NY. 552 pages.
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- Pearson, T. G., C. S. Brimley, and H. H. Brimley. 1959. Birds of North Carolina. Revised by D. L. Wray and H. T. Davis. N. C. State Mus. Nat. Hist., Raleigh, NC. 434 pages.
- Peterson, R. T. 1947. A Field Guide to the Birds. Houghton Mifflin Co., Boston, MA. 230 pages.
- Robbins, C. S., B. Bruun, and H. S. Zim. 1966. Birds of North America. A Guide to Field Identification. Golden Press, N. Y., NY. 340 pages.

Editor's Note: Certain changes in bird nomenclature recently appeared (1976. Thirty-third supplement to the AOU check-list of North American birds, Auk 93:875-879) which affect the names of a number of species in the following list and accounts. They are:

Ictinia misisippiensis reverts to *I. mississippiensis*

Thalasseus and *Hydroprogne* are merged in *Sterna*

T. maximus becomes *S. maxima*

T. sandvicensis becomes *S. sandvicensis*

Dendrocopos is merged in *Picoides*

Spinus pinus becomes *Carduelis pinus*

Species List

Species	Status
Pelecaniformes	
<i>Anhinga anhinga</i> , Anhinga 347	Threatened
<i>Pelecanus occidentalis</i> , Brown Pelican 338	Endangered
<i>Phalacrocorax auritus floridanus</i> , Double-crested Cormorant 348	Threatened
Ciconiiformes	
Ardeidae	
<i>Ardea herodias</i> , Great Blue Heron 369	Special Concern
<i>Botaurus lentiginosus</i> , American Bittern 377	Undetermined
<i>Casmerodius albus</i> , Great Egret 369	Special Concern
<i>Egretta (=Leucophoyx) thula</i> , Snowy Egret 369	Special Concern
<i>Florida caerulea</i> , Little Blue Heron 369	Special Concern
<i>Hydranassa tricolor</i> , Louisiana Heron 369	Special Concern
<i>Ixobrychus exilis</i> , Least Bittern 349	Threatened
<i>Nyctanassa violacea</i> , Yellow-crowned Night Heron 369	Special Concern
<i>Nycticorax nycticorax</i> , Black-crowned Night Heron 369	Special Concern
Threskiornithidae	
<i>Eudocimus albus</i> , White Ibis 369	Special Concern
<i>Plegadis falcinellus</i> , Glossy Ibis 369	Special Concern
Anseriformes	
<i>Anas rubripes</i> , Black Duck 369	Special Concern
Falconiformes	
Cathartidae	
<i>Cathartes aura</i> , Turkey Vulture 350	Threatened
<i>Coragyps atratus</i> , Black Vulture 350	Threatened
Accipitridae	
<i>Accipiter cooperi</i> , Cooper's Hawk 352	Threatened
<i>Accipiter striatus</i> , Sharp-shinned Hawk 354	Threatened
<i>Aquila chrysaetos</i> , Golden Eagle 355	Threatened
<i>Buteo jamaicensis</i> , Red-tailed Hawk 369	Special Concern
<i>Buteo lineatus</i> , Red-shouldered Hawk 357	Threatened
<i>Buteo platypterus</i> , Broad-winged Hawk 377	Undetermined
<i>Circus cyaneus</i> , Marsh Hawk 377	Undetermined
<i>Elanoides forficatus</i> , Swallow-tailed Kite 377	Undetermined
<i>Haliaeetus leucocephalus</i> , Bald Eagle 340	Endangered
<i>Ictinia mississippiensis</i> , Mississippi Kite 377	Undetermined
Pandionidae	
<i>Pandion haliaetus</i> , Osprey 370	Special Concern
Falconidae	
<i>Falco columbarius</i> , Merlin 358	Threatened
<i>Falco peregrinus</i> , Peregrine Falcon 343	Endangered
<i>Falco sparverius</i> , American Kestrel 359	Threatened

Birds -- Species List

Galliformes

Meleagris gallopavo, Turkey 371 Special Concern

Gruiformes

Coturnicops noveboracensis, Yellow Rail 377 Undetermined
Gallinula chloropus, Common Gallinule 371 Special Concern
Laterallus jamaicensis, Black Rail 379 Undetermined
Porphyryula martinica, Purple Gallinule 371 Special Concern
Rallus elegans, King Rail 371 Special Concern

Charadriiformes

Charadriidae

Charadrius melodus, Piping Plover 372 Special Concern
Charadrius wilsonia, Wilson's Plover 372 Special Concern

Laridae

Gelochelidon nilotica, Gull-billed Tern 372 Special Concern
Larus atricilla, Laughing Gull 372 Special Concern
Sterna albifrons, Least Tern 372 Special Concern
Sterna hirundo, Common Tern 372 Special Concern
Thalasseus maximus, Royal Tern 372 Special Concern
Thalasseus sandwicensis, Sandwich Tern 372 Special Concern

Rhynchopidae

Rhynchops niger, Black Skimmer 372 Special Concern

Cuculiformes

Coccyzus erythrophthalmus, Black-billed Cuckoo 379 Undetermined

Strigiformes

Aegolius acadicus, Saw-whet Owl 360 Threatened
Tyto alba, Barn Owl 372 Special Concern

Piciformes

Dendrocopos borealis, Red-cockaded Woodpecker 346 Endangered
Melanerpes erythrocephalus, Red-headed Woodpecker 373 Special Concern
Sphyrapicus varius, Yellow-bellied Sapsucker 379 Undetermined

Passeriformes

Tyrannidae

Empidonax alnorum, Alder Flycatcher 378 Undetermined
Empidonax traillii, Willow Flycatcher 378 Undetermined
Nuttallornis borealis, Olive-sided Flycatcher 362 Threatened

Hirundinidae

Progne subis, Purple Martin 373 Special Concern

Corvidae

Corvus corax, Common Raven 373 Special Concern

Paridae

Parus atricapillus, Black-capped Chickadee 362 Threatened

Sittidae

Sitta canadensis, Red-breasted Nuthatch 374 Special Concern

Certhiidae

Certhia familiaris, Brown Creeper 363 Threatened

Troglodytidae

Thryomanes bewickii, Bewick's Wren 364 Threatened

Turdidae

Catharus (=Hylocichla) ustulatus, Swainson's Thrush Undetermined
Sialia sialis, Eastern Bluebird 375 378 Special Concern

Sylviidae

Regulus satrapa, Golden-crowned Kinglet 375 Special Concern

Laniidae

Lanius ludovicianus, Loggerhead Shrike 375 Special Concern

Vireonidae

Vireo gilvus, Warbling Vireo 365 Threatened

Parulidae

Dendroica cerulea, Cerulean Warbler 366 Threatened

Dendroica petechia, Yellow Warbler 376 Special Concern

Dendroica virens Black-throated Green Warbler 376 Special Concern

Helminthos (=Limnodynops) swainsoni, Swainson's Warbler 376 Special Concern

Helminthos (=Limnodynops) vermivorus, Worm-eating Warbler 378 Undetermined

Mniotilta varia, Black-and-white Warbler 380 Undetermined

Protonotaria citrea, Prothonotary Warbler 376 Special Concern

Icteridae

Icterus galbula, Northern Oriole 380 Undetermined

Fringillidae

Aimophila aestivalis, Bachman's Sparrow 368 Threatened

Ammodramus (=Passerherbulus) henslowii, Henslow's Sparrow 376 Special Concern

Loxia curvirostra, Red Crossbill 380 Undetermined

Passerculus sandwichensis, "Ipswich" Sparrow 376 Special Concern

Poocetes gramineus, Vesper Sparrow 381 Undetermined

Spinus pinus, Pine Siskin 381 Undetermined

SPECIES ACCOUNTS

AVES; PELECANIFORMES; PELECANIDAE
(Pelicans)

Pelecanus occidentalis Linnaeus

BROWN PELICAN

Description: This large bird, the only pelican to nest in eastern North America, is one of the most spectacular components of our coastal avifauna. See Peterson (1947, pp. 8-9) and Pearson et al. (1959, pp. 14-17) for illustrations.

Distribution: Range -- Pacific coast from S British Columbia to S Chile; Atlantic coast from New York westward along Gulf coast, south through West Indies to N South America. Nests along California coast, at several Gulf coast sites, and up Atlantic coast to North Carolina. Range in United States probably not reduced significantly, but numbers down considerably along Pacific and Gulf coasts.

North Carolina -- only known breeding site on Shell Island, Ocracoke Inlet, Hyde Co. Individuals or small flocks found along coast at all seasons.

Reproduction: Brown pelicans first breed at about two years of age. They are colonial nesters, laying two or three eggs in crude nests of grasses or sticks placed on the ground or in low shrub thickets. Incubation requires about four weeks, and young fledge at about nine weeks of age (Palmer 1962). The first published report of Brown pelicans nesting in North Carolina was in 1929, when 14 pairs were found on Royal Shoal in Pamlico Sound near Ocracoke Inlet (Pearson et al. 1942). The next published observation was that of Wolff (1947) for nearby Shell Castle Island. Table 1 provides available data on the history of this colony since 1947. Visits have been few and published information on the nesting population brief. It appears that the colony, while small, is relatively stable, but more careful monitoring is needed.

Status: *Endangered* throughout its range. The U. S. Fish and Wildlife Service estimated Brown pelican populations to be down to about 20-25,000 birds on the Atlantic and Gulf coasts, from a population of about 95,000 prior to 1950. Reproductive success in Pacific and Gulf coast colonies dropped dramatically in the late 1950's and early 1960's. This phenomenon was directly linked to large quantities of pesticide residues in eggs. Some colonies were totally destroyed, and the species was nearly eliminated as a breeding bird in these areas. The Florida and east coast populations suffered less damage, although egg shell thinning has been reported in Florida and South Carolina colonies.

There are no precise estimates of the numbers of Brown pelicans in coastal North Carolina in earlier times. Pearson et al. (1959) commented that "Every summer pelicans to the number of perhaps 200 or more come up the coast from Florida to sojourn for a few months in the waters of Core and Pamlico sounds." Current observations indicate that this bird may be found at all seasons, although more abundant during spring and summer months. Numbers are somewhat greater than indicated above.

Table 1. History of the Brown pelican nesting colony at Ocracoke Inlet, North Carolina.

<u>Year</u>	<u>Date</u>	<u>Nests with eggs</u>	<u>Juveniles</u>	<u>Adults</u>	<u>Site and Reference</u>
1929	?	14?	?	?	Royal Shoal; W. L. Birsch (Pearson et al. 1959)
1947	6 August	14	33	55	Shell Island; Wolff (1947)
1948	19 July	0	0	225	Castle Rock; Shaftesbury (1949)
1948	6 August	0	0	200	Ocracoke vicinity; Shaftesbury (1949)
1957	7 August	35	87	162	Shell Island; Wolff (1958)
1958	?	100+	?	500	Shell Island; Quay (unpublished)
1959	?	?	116	?	Shell Island; Davis (1959)
1960	29 June	6	85	?	Shell Island; Davis (1960)
1961	8 July	2	51	?	Shell Island; Davis (1961)
1965	4 July	?	77	70	Shell Island; Grey (1965)
1970	7 July	?	31	68	North Rock; R. Steiner (Teulings 1970)
1972	23 June	30	17	130	North Rock; Parnell and Soots (unpublished)
1973	30 May	30	22	115	-do-
1974	11 June	41	53	69	-do-
1975	2 June	47	0	84	-do-
1975	5 August	0	39	175	-do-

It appears that the North Carolina nesting population, representing only a small fraction of the total population and at the northern extremity of the breeding range, has remained relatively healthy during this period of general decline. Precise data are lacking, however, and more detailed work is needed. The site of the breeding colony is very fragile, and the birds will soon be required to move if erosion continues. The entire population could be easily lost to storms, direct human interference, or environmental imbalances.

The Brown pelican is protected by the migratory bird treaty and the federal endangered species act. No special steps have been taken in North Carolina, however, to protect the single small breeding colony, and this is urgently needed. Further research must be done to determine the rate of reproductive success in this population, and seasonal surveys along the entire coast are required to assess overall population levels. Increased public education concerning the status and needs of the species in North Carolina should be undertaken.

References: Palmer (1962), Pearson et al. (1959), Peterson (1947); see list following introduction.

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Grey, J. 1965. Banding off Beaufort, North Carolina. Chat 29:107.

Shaftesbury, A. D. 1949. Brown Pelicans in Pamlico Sound. Chat 13:32.

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AVES; FALCONIFORMES; ACCIPITRIDAE
(Hawks, Vultures, and Harriers)

Haliaeetus leucocephalus (Linnaeus)

BALD EAGLE

Description: Everyone is probably familiar with this magnificent hawk, but relatively few people have seen one in the wild. See Peterson (1947, p. 48, Plate 36) for an illustration.

Distribution: Range -- NE Siberia, N Alaska, Mackenzie, Manitoba, SE Quebec, and Newfoundland, south to Baja California, Arizona, New Mexico, S Texas, the Gulf coast, and Florida, and Atlantic coast.

North Carolina -- no nesting records since 1971, despite extensive aerial surveys. Uncommon migrant throughout the state, more often seen along mountain ridges and coast than elsewhere. Wintering records irregular, in coastal areas.

Reproduction: Bald eagles are probably not reproductively mature until four or five years of age, and individuals have been known to live

for as long as 50 years. They mate for life but may not nest every year. In 1936, birds in the Chesapeake Bay area produced an average of 2.1 young for every active nest, but by 1966 this average fell to 1.0. Since that time it has gradually increased to 1.7 (Abbott 1973).

Status: Endangered. The southern race, *H. l. leucocephalus*, is listed as *Endangered* by the federal government and the IUCN, and the species is protected throughout its range in this country. Federal laws have prohibited shooting since 1940.

Bald eagle populations have been declining throughout the United States for many years. Breeding populations have fallen by 50% in most regions since 1946, and the current population estimate for the continental United States is 750 breeding pairs (Snow 1973). In some areas, like North Carolina, the drop has been 90 to 100%, accompanied by 55 to 96% nesting failure. The proportion of young observed in migration in eastern Pennsylvania shifted from 31.5% to 23.1% (Sprunt 1969). In North Carolina the Bald eagle may very well be *Extirpated* as a breeding bird. It was reported by Pearson et al. (1959) to have nested "on Knotts Island, the mainland of Currituck County, on Roanoke Island, at Cape Hatteras, and in the forest of Onslow and Bladen Counties." This same source reported six remaining nest sites in 1959. Mapping of wintering populations indicates that no significant numbers occur in the state (Bystrak 1974). Only a modest number are reported to migrate through here annually, although no systematic monitoring of migration has been done.

Volumes of data on the accelerated rate of decline following widespread use of persistent pesticides and other environmental contaminants (Coon et al. 1970; Krantz et al. 1970; Mulhern et al. 1970; Radcliff 1967; Stickel et al. 1966) suggest this as the major factor. A literature summary of the effects of various chemicals on Bald eagles is in Snow (1973). Other factors cited as instrumental in the decline of this bird are shooting, 54% of reported mortality (Sprunt 1972); past bounties, as in Alaska; electrocution by power lines; and severe weather affecting productivity. Aggressive Great horned owls are also known to evict nesting eagles.

Snow (1973) discussed protective measures already instituted, described ongoing research projects, and made recommendations for protection. Most of these are not applicable in North Carolina because of the apparent absence of breeding groups and the low number of wintering individuals. Future measures here must include research to identify potential nesting sites and winter roost areas, and protection of these sites from habitat destruction. Hikers, hunters, bird watchers, and all other intruders, no matter how benign their purposes, should be kept away from nest trees during the breeding season. All North Carolina sightings of adult Bald eagles between February and early July should be reported so potential nest sites can be checked, preferably by aerial search. Thacker (1971) reported at least 30 Bald eagles in captivity for research projects, and at least 102 housed in zoos. The Patuxent Wildlife Research Center, Laurel, Maryland, has facilities for propagation, and the species has been known to breed in captivity.

The Bald eagle, whose size, beauty, and regal appearance captured the imagination of our early patriots, is not only our national symbol, but for many has come to represent the endangered status of all our native wildlife.

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AVES; FALCONIFORMES; FALCONIDAE
(Falcons)

Falco peregrinus Tunstall

PEREGRINE FALCON

Description: See Forbush (1955, Plate 43) and Peterson (1947, p. 51, Plates 33, 37) for illustrations.

Distribution: Range -- once nearly cosmopolitan; the race *F. p. anatum* bred in scattered areas throughout most of North America, south to N Georgia, west to N Louisiana. Winters from N United States south to Gulf of Mexico, much of Central and South America; populations in eastern United States may have been non-migratory.

North Carolina -- no known breeding populations; modest numbers winter here, probably from Arctic populations, mostly in coastal areas. Migrant individuals can be expected anywhere, but major routes seem confined to barrier beaches and Outer Banks. These generally believed to be birds that breed in Greenland. Fifteen sightings during fall 1974 by personnel at Pea Island National Wildlife Refuge probably reflect only small proportion of transients. No systematic monitoring done to date.

Reproduction: Breeding populations of the Peregrine falcon have probably been extirpated in eastern United States. Berger (1969) drove over 14,000 miles in 1964 checking known nesting sites in this area, but failed to find a single active nest. A few eyries have been reported on cliffs along ridges, gorges, and bluffs from scattered localities in the North Carolina mountains (Spofford 1942). Four of the final eight known nest sites were inactive by 1940, and the last active nest was reported in 1957. Like most high order predators, falcons normally produce small numbers of young, with 3.7 eggs the mean number for the continental United States (Snow 1972). They don't breed until their third year, and are subject to frequent nest failures. In addition, a high percentage of raptors die during their first year before acquiring hunting skills. Data for Peregrine falcons suggest at least 50% young mortality, and some investigators believe 90% may perish. Band-recovery data indicate 20 to 50% adult mortality, but band loss may bias the figures by as much as 10% (Clement 1974).

Status: *Endangered.* The Peregrine falcon is listed in this category by the federal government and the IUCN, and is protected by a treaty with Mexico. It was probably never abundant in the southern Appalachians, and populations suffered from collecting of young and subadults by falconers, shooting, and about 70 years of egg collecting. It appears to have generally withstood these assaults, only to suffer a major decline through toxic agricultural chemicals. Build up of pesticides in reproductive tissues greatly lowered breeding success (Buckley et al. 1969). Indications are that the distinctive eastern population was in trouble well before the mid-1940's, and even minor deleterious effects of chlorinated hydrocarbons could have produced an accelerated mortality rate (Hickey 1969). There are conflicting opinions on the status of migrants.

A ten-year study of Atlantic coast Peregrine falcon movements indicates an 80% decrease in numbers of birds (Clement 1974). The same writer

reported that the Greenland population, which migrates along the North Carolina coast, seems to be in good shape, but there are no base-line data for comparison. Migrants are still being taken by falconers, who have been apprehended on the Outer Banks as recently as the fall of 1975. Shooting is still a major problem, and the birds also suffer myiasis and botulism (White 1963). Although the use of persistent pesticides in the United States has decreased, those wintering in South America are still subjected to the chemicals in large doses. The recently documented decline of pesticides in song birds (Johnston 1974) and other potential falcon prey, and in other species of falcons (Clement 1974), augurs well for future success in re-establishing an eastern population of this bird. The latter investigator reported 29 known breeding pairs of *F. p. anatum* in captivity in eastern United States. The propagation potential for this bird looks fairly promising. Researchers at Cornell University have bred them in captivity, but re-establishment in former habitats has thus far had only limited success.

A number of measures can be taken to facilitate the return of the Peregrine falcon to North Carolina. Aerial surveys of past nesting cliffs and eyries might help determine whether a remnant population exists. There have been several recent reports of birds in the North Carolina mountains during the breeding season. Barrier beaches with minimal human activity seem most attractive to transients, and probably wintering groups. Limiting access to certain islands at specific times may be desirable. Annual monitoring of fall flights at coastal stations could provide much needed base-line data on the extent of local migration and population trends in northern nesting areas. Some investigators suggest "short stopping" migrants and providing them with abundant, clean prey (Clement 1974). Another aspect of management considers restocking historic nesting sites, and perhaps even attempting introduction into cities (Clement provides a thorough discussion). Before such measures can be taken, however, much preliminary information needs to be obtained from potential release areas. Restocking seems to be the best hope for re-establishing the Peregrine falcon as a breeding bird in North Carolina.

It is quite important that we make every effort to assist raptor populations and bring them back to former levels of abundance. Hawks are vital factors in maintaining balanced populations of many small animals. They are top level predators and, as such, good indicators of healthy, stable biological communities. Problems leading to their loss are general problems which could possibly be identified by monitoring trends in their populations. Falcons appear to be particularly susceptible to contamination by pesticides and lead.

Hawks in general, and peregrines in particular, have an aesthetic and dramatic appeal not equalled by most of our other native birds. Every fall thousands of people flock to mountain ridges and other points where hawks appear in number to watch their spectacular flights. Peregrine falcon populations in eastern United States were just beginning to adapt to the urban environment prior to their decline. They would be a welcome addition to our often biologically monotonous, ecologically unbalanced cities.

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AVES; PICIFORMES; PICIDAE
(Woodpeckers)

Dendrocopos borealis (Vieillot)

RED-COCKADED WOODPECKER

Description: See Pearson et al. (1959, Plate 32, opp. p. 234), Peterson (1947, p. 106, Plate 41), and Robbins et al. (1966, p. 183) for illustrations.

Distribution: Range -- resident in mature and old-growth pine woodlands from SE Oklahoma, Arkansas, W Kentucky, and SE Virginia, south to Gulf coast and S Florida. Uncommon and very local through most of current range. Distribution formerly included S Missouri.

North Carolina -- resident in most counties east of and including Halifax, Wake, Montgomery, and Anson; generally uncommon and very local. Major concentrations on Fort Bragg Military Reservation, Sandhills Game Land, and Croatan National Forest. Former state distribution probably similar to current, but much more widespread within that range.

Habitat and Mode of Life: The Red-cockaded woodpecker prefers open pinewoods, and its need for mature pine timber for cavity construction is well documented. The development of a dense hardwood understory causes the bird to abandon its territory, especially when this prohibits easy access to cavities. Home range may vary from 25 to over 150 acres, depending on timber type, stand density, and the number of birds.

Reproduction: One brood is raised per year, and a clutch normally consists of three or four eggs, but usually only one or two young fledge. There is only one pair bond, but often three or more adults will tend a single brood. Nest and roost cavities are constructed in living pines.

Status: *Endangered* throughout its range. It is so listed by the federal government and IUCN. The Red-cockaded woodpecker was probably the most common woodpecker in the southeastern pine barrens prior to colonial times, when virtually all of eastern North Carolina, except swamplands, was dominated by an open pine forest. The almost total destruction of the original forest during the late 1800's and early 1900's greatly depleted its numbers, and restricted it to isolated pockets within its range. Overcutting, lack of reforestation, and extensive fire suppression have allowed much of the former pinelands to become dominated by hardwoods or mixed pine-hardwood forests. Current rotation timber management, and continued hardwood encroachment on mature pine stands, indicate that the decline of available habitat and the Red-cockaded woodpecker is still underway. Based on our knowledge of existing concentrations, the North Carolina population is estimated at between 1,000 and 1,200 birds. Approximately 60% of the total is concentrated in the Greater Sandhills (mainly Cumberland, Harnett, Hoke, Moore, Richmond, and Scotland counties).

Cavity trees and varying amounts of adjacent land are protected from logging on most federal lands in North Carolina, and on the Sandhills Game Land and Weymouth Woods - Sandhills Nature Preserve. Extensive understory control is underway at Weymouth Woods. Most management procedures on federal and state lands are in the development stage.

Other protective measures can be taken to assist this bird in North Carolina. A survey to locate existing sites is needed. Cavity tree sites and adjacent tracts should be protected from logging to insure availability of known and potential cavity trees and adequate feeding area. Frequent prescribed burning to eradicate and suppress hardwood understories should be part of the management. Birds should be protected from disturbance during the April through June breeding season.

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AVES; PELECANIFORMES; ANHINGIDAE
(Darters)

Anhinga anhinga (Linnaeus)

ANHINGA

Description: A large, dark bird attaining lengths of 85 to 90 cm (34 to 36 in.). The neck is long, slender, and curved near the body. The bill is straight and sharply pointed. See Pearson et al. (1959, p. 22) and Peterson (1947, p. 12, Plate 3) for illustrations.

Distribution: Range -- breeds from E North Carolina southward to Florida, along Gulf coast, and up Mississippi Valley to NW Tennessee; winters from coastal South Carolina and Gulf coast southward.

North Carolina -- northern limit of distribution; breeds at three sites in Brunswick Co.; one nesting record of two pairs at Lake Ellis, Craven Co.; generally absent in mid-winter. Formerly nested north to Beaufort Co. and inland to Lennon's Marsh, Robeson Co.

Reproduction: There are few counts of nests or nesting birds available, but the nesting range of this species in North Carolina has declined since the 1930's. The largest group of nesting Anhinga's ever recorded in

this state was probably at Lennon's Marsh in the 1940's (Pearson et al. 1959). The age at first breeding is at least two years, and the clutch size ranges from two to five eggs.

Status: *Threatened*. There are few nesting birds in the state, and these are restricted to the larger fresh-water swamps. Considerable nesting habitat has been lost, and this will probably continue. No protective measures are currently in effect.

Remarks: This bird is also commonly known as the Water turkey.

References: Pearson et al. (1959), Peterson (1947); see list following introduction.

AVES; PELECANIFORMES; PHALACROCORIDAE
(Cormorants)

Phalacrocorax auritus floridanus (Audubon) DOUBLE-CRESTED CORMORANT

Description: See Forbush (1955, Plate 10) and Peterson (1947, Plate 3) for illustrations.

Distribution: Range -- breeds in SE North Carolina, possibly South Carolina, Florida, and along Gulf coast to Texas; winters from S Texas and Florida to Bahamas and West Indies.

North Carolina -- northern limit of range; a few pairs breed at Lake Ellis, Craven Co.; non-breeding individuals may summer from lower Neuse River southward along coast to South Carolina. Winter range unknown because this race cannot be distinguished in the field from *P. a. auritus*, which is common in coastal areas in winter. As a summering and breeding species, this bird was formerly more common in the state.

Reproduction: Pearson et al. (1959) reported on the number of occupied nests at the only known nesting site in the state, Great Lake, Craven County, for five separate years between 1898 and 1948:

<u>Date</u>	<u>Number of Nests</u>
25 May 1898	150
18 June 1909	123
Summer 1911	159
11 June 1939	33
Summer 1948	35

Lake Ellis, Craven County, was the only nesting site in the state in 1973, and there were 12 occupied nests there in the summer of that year (R. Soots, pers. comm.). Clutch size is two to four eggs.

Status: *Threatened* as a breeding species. A total nesting population of 12 pairs at a single known location indicates an extremely precarious situation. The subspecies has shown a steady decrease in North Carolina since the early 1900's, and the subjective impression of a number of different observers is that there has been a general decrease of summering cormorants along our coast. The reasons for the decrease of nesting and summering birds are unknown, but statistically significant eggshell thinning occurred in the Double-crested cormorant between 1946 and 1969-70, perhaps due to chlorinated hydrocarbons (Faber and Hickey 1973). The current nesting location on Lake Ellis, at Camp Bryan, is the site of a private hunting club. Access to the area is strictly limited, and all non-game species of wildlife are protected.

References: Forbush (1955), Pearson et al. (1959), Peterson (1947); see list following introduction.
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AVES; CICONIIFORMES; ARDEIDAE
 (Herons and Bitterns)

Ixobrychus exilis Gmelin

LEAST BITTERN

Description: A small, unique heron of freshwater marshes, attaining lengths of 28 to 36 cm (11 to 14 in.). Illustrations are provided in Forbush (1955, Plate 21) and Peterson (1947, Plate 21).

Distribution: Range -- breeds from N United States and SE Canada, south through Mexico, Central America, Bahamas, Greater Antilles, and South America to Paraguay and Brazil. Wanders north to SW Saskatchewan, Manitoba, S Quebec, and Newfoundland. North American races winter from California, S Texas, and central Florida south to Columbia.

North Carolina -- fairly common breeding species in freshwater marshes along coast and major rivers; uncommon to rare in freshwater marshes of inner Coastal Plain, Piedmont, and possibly in mountain valleys. Formerly much more widespread inland.

Reproduction: The Least bittern produces one brood a year, and normal clutch size is four to five eggs.

Status: *Threatened*. This assessment is essentially based on the low inland population and the continued destruction of habitat for the species. The inland decline is caused by draining of marshes, and flooding of the same kinds of habitats by the creation of deep-water reservoirs. The species prefers cattail marshes, and these are rare around man-made lakes because of steep banks and deep water. No protective measures are now in effect, and survival of this bird will depend on protection of marshes containing *Typha* and/or *Scirpus*.

References: Forbush (1955), Pearson et al. (1959), Peterson (1947); see list following introduction.
Bent, A. C. 1926. Life histories of North American marsh birds. U. S. Nat. Mus. Bull. 135. 490 pages.

AVES; FALCONIFORMES; CATHARTIDAE
(American Vultures)

Cathartes aura (Linnaeus)

TURKEY VULTURE

Coragyps atratus (Bechstein)

BLACK VULTURE

Description: Large, dark birds of characteristic soaring habits. Illustrations and field marks of each are provided in Pearson et al. (1959, p. 93, Plate 14) and Peterson (1947, pp. 39-40, Plate 35).

Distribution: Range -- Turkey vulture occurs from S Canada south through United States to Greater Antilles, Central America, and Straits of Magellan, South America. Black vulture resident in tropical and warm temperate portions of Western Hemisphere.

North Carolina -- both occur statewide; Turkey vulture less abundant, and Black vulture uncommon, in mountains.

Reproduction: These birds nest on the ground, and require 10 to 14 weeks from egg laying to fledging. The eggs and young are thus vulnerable to predators for an extended period, a fact which reduces nesting success. Both species lay one to three eggs, usually two.

Status: *Threatened*. This assessment is largely subjective, since hard data on past distributions and densities are simply not available. The early literature gives the impression that vultures were once abundant throughout most of North Carolina, referring to large numbers in roosts and feeding flocks. This is seldom the case today, and both species are in serious trouble here, particularly the Black vulture. Most Committee members have witnessed a decline in vulture numbers in their areas of experience, and Carter (1971) called attention to a considerable decline in the Sandhills. Prior statements of concern include those of Seeman (1929), who noted that both species were not as common as they once were in the Durham area, and Biggs and Shelburne (1939), who mentioned a decline in Turkey vultures in the Washington area. The latter authors,

however, referred to Black vulture flocks containing up to 90 birds. Groups of this size are a rarity in North Carolina today, although a roosting flock estimated at around 200 birds was seen along the Roanoke River in northwest Bertie County on 11 March 1976 by Merrill Lynch. Bystrak (1974) plotted winter densities from 1972 Christmas Bird Count data. For the Turkey vulture he showed a density of less than one bird per ten party-hours over nearly the entire state. In the northwestern portion there were no vultures reported, while in the northeast there were one to five birds per ten party-hours. For the Black vulture he indicated a density of less than one bird per ten party-hours in the southeastern portion and one local Piedmont site, with none reported from the rest of the state. Interestingly, densities were greater in states immediately adjacent to North Carolina.

There are a number of factors that could have contributed to this apparent decline of vultures. Extensive development, mortality from road kills, shooting, and nest destruction, possible pesticide effects, and an inadequate food supply, are among them. Sanitation laws require that dead domestic animals be buried within 24 hours of death. This practice is disadvantageous to vultures, especially the Black vulture, which feeds in flocks and prefers larger animals than the Turkey vulture. Although a great many animals of various kinds are killed on roads, heavy traffic precludes their consumption by birds.

Remarks: A concerted effort is badly needed to monitor vulture populations and assess their numbers, and identification of causative factors in their decline is imperative. In addition to their other positive features, these birds are important scavengers and vital agents in nutrient recycling. See Zimmerman (1975) for augmented feeding.

References: Pearson et al. (1959), Peterson (1947); see list following introduction.

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AVES; FALCONIFORMES; ACCIPITRIDAE
(Hawks and Harriers)

Accipiter cooperii (Bonaparte)

COOPER'S HAWK

Description: See Peterson (1947, p. 43, Plates 33, 37) and Robbins et al. (1966, pp. 68, 80) for illustrations.

Distribution: Range -- breeds across S Canada and N United States, from Maine and New Brunswick to British Columbia, into NW Wyoming, south to Baja, NW Mexico, S central Texas, east to central Florida. Winters throughout United States and Mexico, to Central America.

North Carolina -- formerly common throughout as breeding species; current breeding distribution unknown, but probably present in small numbers over most of state. Transient throughout, most commonly encountered migrating along coast or mountain ridges. Winters over entire state.

Reproduction: Good data on past and present numbers of nesting hawks in North Carolina are lacking. Twenty-four successful nests studied in western Pennsylvania between 1947 and 1964 averaged 3.2 young fledged (Schrivier 1969). Nest failure has increased.

Status: *Threatened*. Although there has been no systematic monitoring of hawk migrations in North Carolina, it is clear from long range records kept farther north that populations have declined (Spofford 1969). Brown (1973) statistically analyzed winter population trends specifically in Cooper's hawk in 45 states, and found a sharp decrease in all areas except California. In a five year period ending in 1971, there was a 12% decline in wintering individuals in North Carolina. This was one of the commonest hawks in the central Atlantic states during the 1940's and early 1950's, but is now one of the rarest. Records at the North Carolina State Museum of Natural History show that it was a rather common breeding species in the Raleigh area prior to the mid-1950's. Since that time few records are known from Wake County. During the 1974 Christmas Bird Count, 463 observers combed over 4,400 miles of North Carolina, but only 10 sightings of Cooper's hawk were recorded. Of 966 migrating hawks tallied in the fall of 1975, only 7 were this species (D. S. Lee, unpub. observ.). The obvious rarity of this bird, generally considered common 30 years ago, is strong evidence that the species is in trouble. As early as 1972 it was placed on the "Blue List," an early warning system for species showing substantial reduction in numbers (American Birds 1972).

The reasons for the decline of Cooper's hawk are diverse and difficult to pin-point, but known contributors include egg destruction by raccoons and crows, early embryonic death, loss of fertility, and production of thin-shelled eggs (Schrivier 1969, Snyder 1974). The latter investigator reported that shells of recently examined eggs were more fragile and 16% thinner than the average for eggs collected prior to 1974. Concentrations of DDE in unhatched eggs suggest that persistent pesticides may be the major cause of decline (Snyder et al. 1973). Shooting is also a serious problem because of the bird's reputation for raiding chicken yards. Since Cooper's hawk typically nests in second growth forest (Shrivier 1969, Bent

1937) and will, at least sometimes, use relatively small stands of timber near residential areas (D. S. Lee, unpub. observ.), habitat loss may not be a significant factor in reduction.

Like all hawks, this species is protected against shooting. Recent bans on DDT and other persistent pesticides may help prevent further damage from that source. Shriver (1969) found that metal guards around nesting trees successfully prevented raccoons from raiding nests. New methods in chicken production now limit accessibility of domestic fowl to predators and should limit killing of hawks in poultry areas.

Nesting surveys in North Carolina are an urgent research need. The propagation potential for this species is unknown, and the number in captivity is unknown but probably few.

Remarks: Hawks are recognized as important factors in maintaining balanced populations of many smaller animals. As top level predators they are good indicators of healthy, stable biological communities.

- References: Peterson (1947), Robbins et al. (1966); see list following introduction.
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Accipiter striatus Vieillot

SHARP-SHINNED HAWK

Description: See Peterson (1947, pp. 42-43, Plates 33, 37) and Robbins et al. (1966, pp. 68, 80) for illustrations.

Distribution: Range -- breeds from NW Alaska and N Canada south to Mexico and California, east to SE United States. Winters from S British Columbia, SE Canada, N United States, south to Gulf coast and Florida, through Mexico to Central America. Accidental in West Indies.

North Carolina -- breeding range unknown, but apparently more geographically restricted than in past. Formerly uncommon breeder in Piedmont and mountains. Winters throughout state, and statewide as transient, with major concentrations along coast, and mountain ridges.

Reproduction: The species usually lays four or five eggs, but little information is available on typical numbers of young successfully fledged. The size of the North Carolina breeding population is unknown, and the bird is rarely seen here during the nesting season. Pearson et al. (1959) reported only five nesting records for the state.

Status: *Threatened.* The Sharp-shinned hawk is relatively common as a winter bird, but no accurate census data are available. Its secretive nature makes use of Christmas Count numbers unreliable for analysis of winter populations, and also makes nesting census difficult. As a transient it is seasonally abundant, and as many as 500 migrants have been seen in a day of observations along the Outer Banks. Movements of similar intensity probably also occur in the mountains. Migrants are more easily observed than wintering or breeding birds, and most North Carolina population estimates are based on data obtained from transients. The species has never been a common breeder in this state, but it now appears to be even rarer than before, judging from the lack of recent late spring and early summer records. Researchers at other sites have reported marked decline in numbers (Spofford 1969). As early as 1972 it was a candidate for the "Blue List" of birds that have shown a significant decline in numbers (American Birds 1972). Such environmental contaminants as organochlorides and heavy metals are considered a major factor in reproductive failures (Snyder et al. 1973). Shooting continues to be a problem. Wintering populations in the United States are also reduced, but this decline may have leveled off since 1965, especially in the west (Brown 1973).

All hawks are protected from shooting. Recent bans on certain pesticides may aid this species and others to make a comeback. Decreases in the pesticide burden of song birds (Johnston 1974) and other prey species is promising for slow recovery of predator populations. The propagation potential for the Sharp-shinned hawk is unknown, and there is no information on the number in captivity, although it is probably small.

Since this bird is so widely distributed as a wintering species and so irregular as a breeding resident, it is difficult to suggest any protective measures that would be effective. Continued education against shooting hawks would be helpful. Breeding surveys, done by someone experienced at locating this secretive bird, are urgently needed in North Carolina.

Remarks: Large numbers of Sharp-shinned hawks migrate along the coastal islands of North Carolina, nearly all of them immatures (D. S. Lee, in manuscript). Annual monitoring of these flights could give some indication of yearly nesting success of northern populations.

References: Pearson et al. (1959), Peterson (1947), Robbins et al. (1966); see list following introduction.
 American Birds. 1972. The Blue List for 1973. Amer. Birds 26(6):932-933.
 Bent, A. C. 1937. Life histories of North American birds of prey. U. S. Nat. Mus. Bull. 167, Part 1:95-111.
 Brown, W. H. 1973. Winter population trends in the Marsh, Cooper's, and Sharp-shinned hawks. Amer. Birds 27(1):6-7.
 Johnston, D. W. 1974. Decline of DDT residues in migratory song-birds. Science 186:841-842.
 Snyder, N. C. N., H. A. Snyder, J. L. Lincer, and R. T. Reynolds. 1973. Organochlorides, heavy metals and the biology of North American accipiters. BioScience 23(5):300-304.
 Spofford, W. R. 1969. Hawk Mountain counts as population indices in northeastern America. In: J. J. Hickey (Ed.). Peregrine Falcon Populations; Their Biology and Decline. Univ. Wisconsin Press, Madison, WI. pp. 323-332.

Aquila chrysaetos (Linnaeus)

GOLDEN EAGLE

Description: For illustrations of this large bird see Forbush (1955, Plate 41), Peterson (1947, Plate 36), and Robbins et al. (1966, pp. 76-77).

Distribution: Range -- Alaska, across Canada to Newfoundland, south to central Mexico; east slope of Rocky Mountains to Pacific Ocean; New Brunswick south through the Appalachian Mountains.

North Carolina -- largely confined to high mountain regions, and most often seen during fall and winter. Overwintering adults and immatures likely occur throughout mountains, especially near large, open habitats like balds. Consistently reported from Shining Rock Wilderness, which is largely grass and blueberry bald. Such areas are large and remote. Apparently authentic reports from near headwaters of Nantahala River, Macon Co.; vicinity Shining Rock Wilderness, Haywood Co.; Sandymush Bald, Buncombe Co.; Whigg Meadow, Graham Co.; near Mt. Pisgah, Haywood Co. Single bird observed over Jones Knob in Plott Balsams on Oct. 18, 1969 by Simpson (1976). Occasional summer reports; W. Zeedyk (pers. comm.) reported an adult near Joyce Kilmer Memorial Forest on July 21, 1972.

Reproduction: There are insufficient data to conclude that a breeding population now exists in North Carolina, and the literature is inconclusive as to the bird's former breeding status in the state.

Brewster (1886) reported that pairs of Golden eagles were frequently seen in the mountains, and stated "They are said to breed on inaccessible cliffs and ledges of the higher mountains ..." His information seems to have been second-hand. Cairns (1891) made somewhat similar claims, but did not specify actual nest locations, egg dates, and other relevant data. There are several additional indirect accounts of this eagle as a breeding species in North Carolina, and it seems likely that lack of supportive data is due to the small number of observers and general inaccessibility of the habitat. The Golden eagle is known to build a large nest of sticks, and to lay from one to four eggs.

Status: *Threatened*. This determination is based on the apparent small size of the North Carolina population, its unknown breeding status, and the general trend towards loss of isolated habitat. The bird was listed as *Rare* in the preliminary list of endangered species in North Carolina (DNER 1973), and the statement made that the Appalachian population had declined greatly. Limited observations make it difficult to estimate current population size. A U. S. Forest Service study in 1974 and 1975 confirmed the presence of a minimum winter population of two immatures in the vicinity of Shining Rock Wilderness. Only one other sighting was reported during this period, in Macon County. The North Carolina winter population is estimated at less than 20 birds, and may be considerably fewer.

Research on population size and trends, using mark-recapture and radiotelemetry tactics, is urgently needed. We also need to determine the origins of North Carolina birds, the location of key habitat areas, and the summer distribution, especially of any breeding pairs. Home range size and other spatial requirements also need to be determined.

References: Forbush (1955), Peterson (1947), Robbins et al. (1966); see list following introduction.
Brewster, W. 1886. An ornithological reconnaissance in western North Carolina. *The Auk* 3(1):94-112.
Cairns, C. J. 1902. List of the birds of Buncombe County, North Carolina. Privately printed. Dated 6 July 1891.
DNER. 1973. Preliminary list of endangered plant and animal species in North Carolina. Dept. Natural Econ. Resources, Raleigh, NC.
Simpson, M. B., Jr. 1976. Birds of the Plott Balsam Mountains of North Carolina. *Chat* 40(3):53-62.

Buteo lineatus (Gmelin)

RED-SHOULDERED HAWK

Description: See Forbush (1955, Plate 40), Peterson (1947, Plates 32, 34), and Robbins et al. (1966, p. 71) for illustrations.

Distribution: Range -- N California to NW Baja; from E Nebraska, Minnesota, Ontario, and S Quebec south to Gulf coast, Florida, and Vera Cruz.

North Carolina -- resident east of mountains; winter visitor throughout.

Reproduction: There is little information on breeding and nesting in North Carolina. Stewart (1949) found a breeding density of one pair per 0.8 square miles in suitable floodplain habitats in Maryland. From one to four eggs may be laid, and Stewart (1949) found an average of 2.7 young in 47 occupied nests following the hatching period. Fairly large trees are preferred as nest sites, and Stewart (1949) failed to find this species nesting out of the floodplain habitat.

Status: *Threatened*. Bystrak (1974) plotted winter densities from 1970-72 Christmas Bird Count data, and found 0.1 to 0.5 birds per 10 party-hours for most of North Carolina. On the lower Piedmont and upper Coastal Plain, and in the northeastern corner of the state, the average density was slightly greater, with 0.5 to 2.0 birds per 10 party-hours. Brown (1971) analyzed data from nearly 10,000 Christmas Bird Counts reported in *Audubon Field Notes* for 1950-69. He showed a decrease of this hawk in all states except California, where there was no change, and West Virginia, where there was a slight increase. Rhode Island showed a 95% decrease, Connecticut and New York records dropped by 85-94%, Massachusetts and New Jersey by 75-84%, and there was a 55-64% decrease in Delaware. North Carolina's wintering population experienced a 65-74% decrease in this period. Carter (1971) mentioned a decline in breeding populations in the Sandhills. The overall decline of this hawk, and especially the wintering population in North Carolina, is cause for great concern.

One of the primary ecological requirements for the Red-shouldered hawk is a "combination of fairly extensive floodplain forest with adjacent clearings" (Stewart 1949). This author also found that the width of the floodplain was an important factor in governing densities of the bird. The species appears to be stable in areas of the Roanoke and Chowan rivers and their major tributaries where clear-cutting has not been extensive, but in certain areas of northeastern North Carolina where breeding densities were good, no breeding birds could be found after clear-cutting (M. Lynch, pers. comm.). Thus, its decline may be closely tied to the destruction of floodplains and swamp forests, and extensive habitat removal in the north may be related to North Carolina's losses. Pesticide concentration may also have had an effect on this species. Shooting, capture for falconry, nest destruction, road kills, and similar problems must also be considered, but these are probably minimal sources of loss and could probably be tolerated by a stable breeding population. State and federal laws make shooting of hawks illegal.

The major conservation tactic for this species will have to be aimed at protection of floodplain and swamp forest to maintain adequate breeding habitat. In Franklin County, North Carolina, the bird has been

found nesting relatively close to roads where adequate wet forest was available (E. Potter, pers. comm.). Extensive cutting of hardwood areas, even if reforested, prevents these birds from using such areas for a great many years. North Carolina is fortunate in still having an abundance of breeding habitat of this type, and efforts should be made to maintain this situation. Further destruction could make this hawk an endangered species.

Proper censusing of Red-shouldered hawks to locate nesting territories should be undertaken, as a step towards preventing the inadvertent destruction or severe alteration of these sites. This can be done with a high degree of accuracy, since the birds indulge in very vocal territorial displays, and since nests themselves can be located early in the season before extensive foliage develops. Nest location by air is also practical, since the birds nest in close proximity to streams and swamps.

References: Forbush (1955), Peterson (1947), Robbins et al. (1966); see list following introduction.

Brown, W. H. 1971. Winter population trends in the Red-shouldered hawk. Amer. Birds 25:813-817.

Bystrak, D. (Ed.). 1974. Wintering areas of bird species potentially hazardous to aircraft. Nat. Audubon Soc.-U. S. Fish Wildl. Serv. Special Rpt. 156 pages.

Carter, J. H., III. 1971. Birds of the central Sandhills of North Carolina. Chat 35:91-105.

Stewart, R. E. 1949. Ecology of a nesting Red-shouldered hawk population. Wilson Bull. 61:26-35.

AVES; FALCONIFORMES; FALCONIDAE
(Falcons)

Falco columbarius Linnaeus

MERLIN

Description: See Forbush (1955, Plate 44) and Peterson (1947, Plates 33, 37) for illustrations.

Distribution: Range -- breeds from tree line in N Canada to N border of United States; migrant across E North America; winters from Virginia to N South America.

North Carolina -- fall migrant, mainly coastal, with largest concentrations along Outer Banks; a few winter in coastal areas.

Status: *Threatened.* The main reason for assigning the Merlin to this status in North Carolina is its presence on the "Blue List" (American Birds 1972), which reflects the fact that observers in the northeast have noted a decline in numbers over the past several years. Examination of Christmas Bird Counts for coastal North and South Carolina from 1959 to 1973 showed this species occurring with such low frequency that no population trends could be determined for wintering birds. Most counts recorded none, or one, except Pea Island, where the numbers ranged from four to six.

Although not a breeding bird in North Carolina, the Merlin is subjected to deleterious pressures while here. Current state and federal laws ostensibly protect birds of prey, but shortage of enforcement manpower and difficulty in securing prosecutions make them hard to enforce. Illegal trapping of migrants for falconry continues on the Outer Banks, and is a threat to this species. Birds are occasionally shot, especially when mistaken for Mourning Doves by inexperienced gunners. Pesticides have probably also had an adverse effect on this top-level predator, although recent reductions of residues in birds which are prey species (Johnston 1974) is encouraging.

Remarks: This species is also known as the Pigeon hawk. Like most raptors, the Merlin may serve as an indicator of environmental conditions of potential harm to humans. In addition, its role as a predator on certain bird species serves to keep populations of these birds in check. It appears to be the only predator capable of catching such fast-flying species as swallows and swifts.

References: Forbush (1955), Peterson (1947); see list following introduction.

Johnston, D. W. 1974. Decline of DDT residues in migratory song-birds. Science 186:841-842.

Falco sparverius Linnaeus

AMERICAN KESTREL

Description: See Forbush (1955, Plate 44) and Peterson (1947, Plates 33, 37) for illustrations.

Distribution: Range -- breeds from Florida and Gulf of Mexico north to Newfoundland, S Quebec, and Saskatchewan; winters north to S Ontario.

North Carolina -- current breeding distribution unclear, but apparently once statewide as a breeding species; winter resident throughout; numerous records of summering individuals since 1960.

Reproduction: Pearson et al. (1959) cited numerous North Carolina breeding records, from the coast to the mountains. They spanned the period 1898 to 1953, with most from the early 1900's. Further literature review reveals that two immatures were seen with two adults at the Wilmington shipyard, New Hanover County, on 28 June 1960 (Chat 1960). In addition, a nesting pair was reported seen near North Wilkesboro, Wilkes County, in the summer of 1974, but no nest or eggs were reported (American Birds 1974). A pair was seen in Ashe County in June 1973 and again in June 1975, but no evidence of nesting was observed. The American kestrel nests once a year, generally in tree cavities, and usually lays four eggs.

Status: *Threatened.* Although breeding population numbers are not known for the state, the absence of recent nesting records leads us to conclude that they are presently low. Pearson et al. (1959) clearly indicated that this bird was a regular breeding species through the late 1930's, but there have been no records in the last 15 years. In the

absence of reliable information, we can only speculate on the reasons for this decline. J. H. Carter (pers. comm.) reports seeing the Kestrel in the Sandhills only in large, clear-cut areas away from cultivated fields. He suspects that heavy pesticide sprayings around these fields have had a detrimental influence. Shooting, road-kills, nest destruction, and capture for falconry, may all have contributed to the bird's decline, but there is no direct evidence. State and federal laws prohibit the shooting of falcons, but are difficult to enforce.

Efforts to assist the recovery of the American kestrel must be made, but considerable research is required to determine the best methods. Breeding requirements must be assessed, and the factors adversely influencing reproduction identified. The Kestrel feeds chiefly on grasshoppers and other insects, and thus can be expected to accumulate a considerable pesticide load through bioconcentration. The use of less toxic, biodegradable pesticides in agricultural regions could aid in its recovery. Erection of nest boxes in favorable localities may also be a realistic management procedure, since Kestrels are known to use such sites in some areas. The propagation potential and number of birds in captivity are both unknown for this species.

Remarks: This bird, also known as the Sparrow hawk, is of considerable value for its habit of preying on insects and small mammals. In addition, all other comments previously made concerning the virtues of raptors apply to this small, attractive falcon.

References: Forbush (1955), Pearson et al. (1959), Peterson (1947); see list following introduction.
American Birds. 1974. Southern Atlantic Coast Region. Amer. Birds 28(5):890.
Chat. 1960. Briefs for the Files. Chat 24:105.

AVES; STRIGIFORMES; STRIGIDAE
(Typical Owls)

Aegolius acadicus (Gmelin)

SAW-WHET OWL

Description: A small owl, 17.8 to 21.6 cm (7 to 8 1/2 in.) long, without ear tufts. See Forbush (1955, Plate 47) and Peterson (1947, Plate 39) for illustrations.

Distribution: Range -- breeds in coniferous and mixed forests from Canada and S Alaska south to mountains of S California, Arizona, and Mexico (Veracruz and Oaxaca), and several parts of central United States; in E United States occurs locally in spruce and fir forests of central and southern Appalachians, in West Virginia and Maryland, south to W North Carolina. Winters through breeding range, and south to Louisiana and Florida.

North Carolina -- southern extremity of breeding range, in spruce-fir forests of Great Smoky, Balsam, Plott Balsam, and Black

mountains, Pisgah Ridge, and Roan Mountain. Former distribution not known, but probably corresponded to distribution of breeding habitat. Rare winter resident, but records widespread.

Reproduction: Although no eggs or flightless young have yet been found in North Carolina, there is indirect evidence that this owl breeds in high altitude spruce-fir forests of the mountains. Peake (1965) found an immature bird on Richland Balsam, Jackson County, and Simpson (1972) reported a juvenile found on 2 September 1965 at Mt. Mitchell State Park, Yancey County. He viewed it as unlikely that this bird, and Peake's, were migrants. Elsewhere the species is known to nest in cavities in trees, especially those vacated by woodpeckers, and to produce from four to seven eggs, usually six (Bent 1938).

Status: *Threatened*. The Saw-whet owl population in North Carolina is probably between 50 and 100 pairs, although only 20 calling stations are known. At least 90% of the spruce-fir type of the southern Appalachians has been destroyed by fire and logging (Korstian 1937), and the balsam wooly aphid, *Chermes piceae*, devastated the Fraser fir in North Carolina. These factors undoubtedly caused major constrictions of the range of this owl and a decline in total numbers. Destruction of breeding habitat still continues.

Much of the required habitat is within national and state parks, wilderness areas, and the Blue Ridge Parkway, and complete protection of spruce-fir forests in at least these areas should be attempted. This would protect not only the Saw-whet owl, but the Black-capped chickadee, the Brown creeper, the Olive-sided flycatcher, and other animals of concern in western North Carolina.

References: Forbush (1955), Peterson (1947); see list following introduction.

- Bent, A. C. 1938. Life histories of North American birds of prey. U. S. Nat. Mus. Bull. 170, Part 2:232.
- Korstian, C. F. 1937. Perpetuation of spruce on cut-over and burned lands in the higher southern Appalachian Mountains. Ecol. Monogr. 7: 125-167.
- Peake, R. H., Jr. 1965. Saw-whet owls in Jackson County, North Carolina. Chat 29:110-111.
- Simpson, M. B., Jr. 1968. The Saw-whet owl: Breeding distribution in North Carolina. Chat 32:83-89.
- _____. 1972. The Saw-whet owl population of North Carolina's southern Great Balsam Mountains. Chat 36:39-47.
- Stupka, A. 1963. Notes on the birds of Great Smoky Mountains National Park. Univ. Tennessee Press, Knoxville, TN.

AVES; PASSERIFORMES; TYRANNIDAE
(Tyrant Flycatchers)

Nuttallornis borealis (Swainson)

OLIVE-SIDED FLYCATCHER

Description: See Forbush (1955, Plate 55), Pearson et al. (1959, Plate 33), and Peterson (1947, Plate 42) for illustrations.

Distribution: Range -- boreal; breeds in coniferous forests of Canada, N United States, and western mountains; in E United States occurs in spruce, fir, and hemlock forests of central and southern Appalachian Mountains.

North Carolina -- southern limit of breeding, in spruce-fir forests of Great Smoky Mountains; formerly in same habitat in Black Mountains and on Roan Mountain, and in hemlock forests of Highlands Plateau and Blue Ridge Mountains.

Reproduction: The Olive-sided flycatcher makes a shallow nest on the horizontal limb of a conifer, usually high above the ground. Each female commonly lays three eggs (Pearson et al. 1959).

Status: *Threatened*. Never common in North Carolina, the Olive-sided flycatcher's range has been constricted by habitat destruction and human intrusion. At present, only two or three individuals are reported during any given breeding season, and these have been confined to the Great Smoky Mountains. As with the Saw-whet owl, much of the required habitat is within state and federally owned lands, where complete protection of the conifer forests should be undertaken.

References: Forbush (1955), Pearson et al. (1959), Peterson (1947); see list following introduction.
Burleigh, T. D. 1935. The present status of the Olive-sided flycatcher in western North Carolina and eastern Tennessee. *Wilson Bull.* 48:13-16.
Cairns, J. S. 1889. The summer birds of Buncombe County, North Carolina. *Ornithol. and Oology* 14:17-23.
Stupka, A. 1963. Notes on the birds of Great Smoky Mountains National Park. Univ. Tennessee Press, Knoxville, TN.

AVES; PASSERIFORMES; PARIDAE
(Titmice)

Parus atricapillus Linnaeus

BLACK-CAPPED CHICKADEE

Description: See Forbush (1955, Plate 90), Pearson et al. (1959, Plate 35), and Peterson (1947, Plate 44) for illustrations.

Distribution: Range -- occurs widely in Canada, N United States, and western mountains; in E United States, breeds locally in spruce-fir

forests of central and southern Appalachian Mountains.

North Carolina -- southern limit; presently occurs only in Great Smoky, N Great Balsam, and Plott Balsam mountains; extirpated from Black Mountains.

Reproduction: This bird nests in holes, usually of its own making and often enlargements of woodpecker probes, in decaying stumps of pine or birch. "Anywhere from 5 to 10 eggs may be found in the chickadee's nest, but 6 to 8 are the commonest numbers, and as many as 13 have been recorded." (Bent 1946).

Status: *Threatened*. This species was formerly more widespread and abundant in North Carolina than it is at present. Fire and logging extirpated it from the Black Mountains through habitat destruction, but it has not been reported from several other ranges where spruce-fir forests still occur. Although found only in association with these communities, the limiting factor in its distribution may be the availability of Yellow birch, *Betula lutea*, which is used for nesting cavities. Destruction of habitat continues.

Much of the breeding habitat is within Great Smoky Mountains National Park and the Blue Ridge Parkway, and this must be fully protected if the Black-capped chickadee is to survive in North Carolina.

References: Forbush (1955), Pearson et al. (1959), Peterson (1947); see list following introduction.
Bent, A. C. 1946. Life histories of North American Jays, Crows, and Titmice. U. S. Nat. Mus. Bull. 191:325.

AVES; PASSERIFORMES; CETHIIDAE
(Typical Creepers)

Certhia familiaris Linnaeus

BROWN CREEPER

Description: See Forbush (1955, Plate 90), Pearson et al. (1959, p. 264), and Peterson (1947, Plate 44) for illustrations.

Distribution: Range -- widespread in Canada, N United States, and western mountains, south to Nicaragua; in E United States, breeds locally in spruce, fir, hemlock, white pine, and deciduous forests in higher elevations of central and southern Appalachian Mountains.

North Carolina -- southern breeding limit; spruce-fir and adjacent hardwood forests of Great Smoky, Black, Balsam, Plott Balsam, and Nantahala mountains, Pisgah Ridge, Grandfather Mountain, and Roan Mountain; hemlock forests of Great Craggy and Blue Ridge mountains; hemlock and white pine forests of Highlands Plateau. Former distribution corresponded to occurrence of breeding habitats.

Reproduction: The Brown creeper nests in natural cavities of a variety of trees, and lays five or six eggs.

Status: *Threatened*. At least 90% of the spruce-fir type has been destroyed by fire and logging (Korstian 1937), and Fraser fir was decimated by the balsam wooly aphid (Amman and Speers 1965). This has resulted in a major constriction of overall range, and a marked decline in total numbers of this bird. The species depends heavily on dead trees for nesting sites and prefers mature and climax forests, where such trees occur naturally. It may be absent from extensive tracts of early and medium second-growth, while climax spruce-fir may have 20 pairs per 100 acres. Destruction of spruce-fir and hemlock forests in the mountain region of North Carolina continues.

As with several of the preceding species, much of the needed habitat is within national and state parks, wilderness areas, and the Blue Ridge Parkway. Protection of nesting habitat is of prime importance in conservation of this species.

References: Forbush (1955), Pearson et al. (1959), Peterson (1947); see list following introduction.

Amman, G. D., and C. F. Speers. 1965. Progress in biological control of the balsam wooly aphid in North Carolina. Southern Lumberman, 15 December.

Korstian, C. F. 1937. Perpetuation of spruce on cut-over and burned lands in the higher southern Appalachian Mountains. Ecol. Monogr. 7: 125-167.

Simpson, M. B., Jr. In preparation. Breeding distribution and ecology of the Brown creeper in the southern Blue Ridge Mountain Province.

Stupka, A. 1963. Notes on the birds of Great Smoky Mountains National Park. Univ. Tennessee Press, Knoxville, TN.

AVES; PASSERIFORMES; TROGLODYTIDAE
(Wrens)

Thryomanes bewickii (Audubon)

BEWICK'S WREN

Description: See Peterson (1947, Plate 47) and Robbins et al. (1966, p. 223) for illustrations.

Distribution: Range -- breeds widely through much of central and N United States; in east, resident in Appalachian region from S Ontario to central Alabama; winters south to E Texas and Louisiana, east to central Florida.

North Carolina -- mountains, southeastern extremity of range; formerly common summer resident, now quite rare.

Reproduction: Bewick's wren nests in nearly any available cavity, including knotholes in fallen trees, openings in man-made structures, and occasionally in brush piles. From 4 to 11 eggs have been recorded, with 7 apparently the average.

Status: *Threatened*. The population of this bird in the North Carolina mountains has declined markedly during this century, and it is now very rare in its former range. The causes of this decline are not positively known, but may include increased urbanization, deforestation, and competition from the House Wren, *Troglodytes aedon*, which has invaded the area in recent decades.

If this wren is to survive in North Carolina, an evaluation of its current population status must be made, and factors contributing to its decline must be identified and corrected.

References: Peterson (1947), Robbins et al. (1966); see list following introduction.

Burleigh, T. D. 1958. Georgia Birds. Univ. Oklahoma Press, Norman, OK.

Stupka, A. 1963. Notes on the birds of Great Smoky Mountains National Park. Univ. Tennessee Press, Knoxville, TN.

AVES; PASSERIFORMES; VIREONIDAE
(Vireos)

Vireo gilvus (Vieillot)

WARBLING VIREO

Description: See Peterson (1947, Plate 47) and Robbins et al. (1966, p. 248) for illustrations.

Distribution: Range -- breeds throughout much of Canada and United States; winters in Mexico and Central America.

North Carolina -- summer resident, locally in Appalachian highlands, and winter migrant farther east; formerly nested in mature hardwood forests, particularly in river flood plains and stream borders in French Broad River basin. Most recent records from New River basin.

Reproduction: This bird constructs a basket-shaped nest, usually high in hardwood trees, and lays three to five eggs, usually four.

Status: *Threatened*. The North Carolina population of the Warbling vireo has declined during the present century, possibly because of destruction of mature riparian woodlands. Part of the area from which most recent records have come may be flooded by a proposed hydroelectric project in Virginia. No specific protective measures are now in effect in North Carolina.

Remarks: Steps must be taken to determine the precise status of populations of this inconspicuous bird, and to accurately evaluate the causes of its apparent decline.

References: Peterson (1947), Robbins et al. (1966); see list following introduction.
Brewster, W. 1883. An ornithological reconnaissance in western North Carolina. Auk 3:173.
Marsh, C., H. LeGrand, Jr., and W. Brown, Jr. 1974. Summer bird records from Ashe and Alleghany counties, North Carolina. Chat 38:1-3.

AVES; PASSERIFORMES; PARULIDAE
(Wood Warblers)

Dendroica cerulea (Wilson)

CERULEAN WARBLER

Description: See Forbush (1955, Plate 83) and Robbins et al. (1966, pp. 251, 265) for illustrations.

Distribution: Range -- breeds in mature upland deciduous and river floodplain forests, from S Ontario, central New York, SE Minnesota, and Nebraska, south to northern parts of Gulf states, chiefly west of Appalachians. Winters in N South America.

North Carolina -- summer resident in floodplain forest along Roanoke River, from Garysburg, Halifax Co., to Windsor, Bertie Co.; also in mountains during breeding season, near Green River, SW Polk Co., and Roaring Gap, Wilkes Co. Formerly bred in W Piedmont at Morganton, Burke Co.; Statesville, Iredell Co.; and Greensboro, Guilford Co. (Pearson et al. 1959).

Reproduction: No specific breeding records are known for this bird in the Piedmont of North Carolina since 1930. Fifteen territorial males were found on 24-25 May 1975 at four sites along the Roanoke River in Halifax, Martin, and Bertie counties by M. Lynch (pers. comm.). An additional 25 such males were seen in the Occoneechee Neck section of Northampton County on 4 May 1975 as part of the Roanoke Rapids Spring Bird Count (LeGrand 1975). Based on these observations, at least 40 breeding pairs were present along a 115 km (72 mi.) stretch of the river between Garysburg and Windsor. Since the entire valley has not yet been censused, no figures are available for the total breeding population. The nest is said to be built in deciduous trees and to be a compact, cup-shaped structure (Pearson et al. 1959). The normal clutch size is 3 or 4 eggs, and it is not known whether the species is single or double brooded.

Status: *Threatened*. This assessment is based primarily on the Roanoke River population, discovered in June 1972 (Lynch 1973). There are no data to document a decline in the population since its discovery, and the status of this species in the mountains is currently undetermined.

However, the Cerulean warbler is a climax community species of mature hardwood forests, and little of this habitat remains today. Thus, this bird can be viewed as a relic of the past, a remnant from the virgin forests which once covered much of eastern United States. The Roanoke River population is unique in being one of two known Coastal Plain breeding groups south of Maryland. The nearest mountain breeding site is over 200 km (125 mi.) away. Habitat along the Roanoke is limited to a 180 m (200 yd.) strip on either side of the river, in relatively undisturbed floodplain forest containing some of the very last stands of virgin timber in eastern North Carolina. Logging operations threaten to destroy much, if not all, of this habitat, and such destruction could annihilate the Cerulean warbler in this area.

As a migratory bird, the Cerulean warbler is protected by state and federal laws. But, no existing laws address the question of habitat destruction, and retention of adequate stands of large trees in the floodplain forest where the bird is still fairly common is a necessity if it is to survive here. Timber companies with land holdings or harvest rights in this area must be made aware of the problem, and encouraged to limit cutting along the river until definitive protective measures can be taken. Establishment of a Research Natural Area or state park in this region is one possible such measure. Research into the breeding biology and ecology of this bird is badly needed, but information is hard to obtain, since it is a species of the treetops where foliage makes observation extremely difficult. The propagation potential and number in captivity are not known.

Remarks: The Cerulean warbler is a species widely sought by bird-watchers and other naturalists for its beauty and the aesthetic nature of its habitat. The Roanoke River population, apparently isolated, is of considerable interest to research biologists.

References: Forbush (1955), Pearson et al. (1959), Robbins et al. (1966); see list following introduction.

- LeGrand, H. E., Jr. 1975. Spring bird count -- 1975. Chat 39:76-89.
Lynch, J. M. 1973. Cerulean warbler found in North Carolina in summer. Chat 37:83-84.
Scott, F. R. 1958. The Cerulean warbler in summer on the Virginia Coastal Plain. Raven 29:118.
Stewart, R. C., and C. S. Robbins. 1958. Birds of Maryland and the District of Columbia. U. S. Govt. Print. Office, Washington, DC.

AVES; PASSERIFORMES; FRINGILLIDAE
(Grosbeaks, Finches, Sparrows, and Buntings)

Aimophila aestivalis (Lichenstein)

BACHMAN'S SPARROW

Description: See Forbush (1955, Plate 94) and Robbins et al. (1966, pp. 307, 317) for illustrations.

Distribution: Range -- breeds from S Missouri, NE Illinois, central Indiana and Ohio, SW Pennsylvania, and central Maryland, south to SE Texas, Gulf coast, and central Florida; an uncommon and local breeder throughout most of range, except parts of South where proper habitat is more abundant. Winters north to NE Texas, central Mississippi and Alabama, N Georgia, and SE North Carolina. Occurs mostly in pine savannas in the South and brushy fields in the North; northern portion of current overall range colonized in late 19th century.

North Carolina -- uncommon and very local in pine savannas in SE and southcentral portions of state; status in N Coastal Plain uncertain; rare in brushy fields in Piedmont. Limits of former statewide distribution probably similar to current limits. Formerly much more common and widespread within range in this state.

Reproduction: Less than 25 breeding pairs of this bird are known outside of Brunswick County. Nests are built on the ground. Two broods are produced annually, and the eggs number three to five per clutch.

Status: *Threatened*. This species was formerly common in pine savannas and other native grassland communities in the southern Coastal Plain and Sandhills, and probably throughout the eastern half of the state. Massive grassland alteration from a variety of sources has seriously depleted its numbers.

Bachman's sparrow is protected by the Migratory Bird Act, but this does not prevent habitat destruction, which is the primary threat to the species. No other protective measures are now in effect, although a preliminary mapping of range on the Fort Bragg Military Reservation is underway. A survey of existing grassland communities to assess the bird's precise status and range is needed, and grasslands containing this species should not be drastically changed. They should, however, be burned every one to three years to prevent hardwood encroachment. This burning must be carried out in winter to avoid disruption of nesting cycles.

Remarks: This species is also known as the Pinewoods sparrow.

References: Forbush (1955), Pearson et al. (1959), Robbins et al. (1966); see list following introduction.
Ashe, W. W. 1894. The Forests, Forest Lands, and Forest Products of Eastern North Carolina. N. C. Geol. Econom. Surv. Bull. No. 5, Raleigh, NC.
Sprunt, A., Jr., and E. B. Chamberlain. 1970. South Carolina Bird Life. Univ. South Carolina Press, Columbia, SC.
Weston, F. M. 1968. Bachman's sparrow. pp. 956-975 In: O. L. Austin, Jr. (Ed.). Life Histories of North American Cardinals, Grosbeaks, Buntings, and Allies. U. S. Nat. Mus. Bull. 237.

All of the birds listed below are of *Special Concern*. The reasons for their being placed in this category are given in the remarks following each group or species listing.

AVES; CICONIIFORMES; ARDEIDAE
(Herons and Bitterns)

<i>Ardea herodias</i> (Audubon)	GREAT BLUE HERON
<i>Casmerodius albus</i> (Linnaeus)	GREAT EGRET
<i>Hydranassa tricolor</i> (Muller)	LOUISIANA HERON
<i>Florida caerulea</i> (Linnaeus)	LITTLE BLUE HERON
<i>Egretta</i> (=Leucophoyx) <i>thula</i> (Molina)	SNOWY EGRET
<i>Nyctanassa violacea</i> (Linnaeus)	YELLOW-CROWNED NIGHT HERON
<i>Nycticorax nycticorax</i> (Linnaeus)	BLACK-CROWNED NIGHT HERON

AVES; CICONIIFORMES; THRESKIORNITHIDAE
(Ibises and Spoonbills)

<i>Eudocimus albus</i> (Linnaeus)	WHITE IBIS
<i>Plegadis falcinellus</i> (Linnaeus)	GLOSSY IBIS

Remarks: Wading birds nest in colonies of a few to several thousand pairs. Colonies are usually restricted to shrubby estuarine islands, except in the case of the Great blue heron, Great egret, and possibly the Night herons. There are only about 40 such colonies of wading birds known in North Carolina, and the destruction of nesting sites could result in great damage. Most of these colonies are now on man-made estuarine dredge islands, the birds having been evicted from mainland sites by human pressures. Almost the entire North Carolina population of the White ibis nests on Battery Island, near Southport. All colonies are very much subject to human interference and are of considerable concern.

AVES; ANSERIFORMES; ANATIDAE
(Swans, Geese, and Ducks)

<i>Anas rubripes</i> Brewster	BLACK DUCK
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Remarks: In the past the Black duck has been one of the most common of the waterfowl using the coastal marshes. In recent years, however, populations appear to be declining. Evidence points to accumulations of pesticides as the factor causing the decline. There is a small breeding population in northeastern North Carolina. Its status is uncertain and needs further investigation.

AVES; FALCONIFORMES; ACCIPITRIDAE
(Hawks and Harriers)

<i>Buteo jamaicensis</i> (Gmelin)	RED-TAILED HAWK
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Remarks: Because of its size, behavior, and relative abundance, the Red-tailed hawk is frequently observed. However, the general

consensus is that it is not as common as it once was, although specific data are lacking. This species is known to nest throughout most of the state and seems to have ample habitat.

AVES; FALCONIFORMES; PANDIONIDAE
(Ospreys)

Pandion haliaetus (Linnaeus)

OSPREY

Remarks: The Osprey nests regularly along the waterways of eastern North Carolina, and may also be seen regularly at inland sites during migrations. An occasional bird will summer on one of the inland reservoirs. It is generally absent from the state during colder winter months. Nesting populations appear to be stable in North Carolina over the past few years. A recent study (Henny and Noltemeier 1975) estimated that 450 pairs nested in the coastal areas of the state in 1974. Studies in the southeastern part of the state between 1969 and 1971 indicate that reproductive success at that time was sufficient to maintain the population (Parnell and Walton, in press).

The Osprey has had serious problems in recent years at many breeding sites. It was nearly extirpated as a nesting bird along the New England coast, and suffered considerable losses in the middle Atlantic states. The problem resulted from concentrations of pesticide residues which caused the laying of eggs with very thin shells. These were easily broken during incubation, and reproductive losses were often great. Recently, with the banning of certain more persistent pesticides, Osprey reproduction appears to be improving. While North Carolina Ospreys seem to have escaped the worst of the pesticide related problems, we must be alert to the possibility that these chemicals could still induce losses here. Another potentially serious problem is the continued development of waterfront property along coastal waterways. This often results in the cutting of trees used for nest sites, or increased disturbance of nesting pairs.

Ospreys often congregate into loose nesting aggregations in especially favorable sites. There are several such places here; Orton Pond, Brunswick County, and Lake Mattamuskeet, Hyde County, are the two best known. Such concentrations are now receiving special attention and protection, either from concerned private owners or governmental units. Should land control change at these sites, however, problems could result.

References: Henny, C. J., and A. P. Noltemeier. 1975. Osprey nesting populations in the coastal Carolinas. *Amer. Birds* 29:1073-1079.
Parnell, J. F., and R. Walton. In press. Osprey reproductive success in southeastern North Carolina. *Proc. 1st N. Amer. Osprey Conf.*, Williamsburg, VA.

AVES; GALLIFORMES; MELEAGRIDAE
(Turkeys)

Meleagris gallopavo Linnaeus

TURKEY

Remarks: At present the wild Turkey still ranges from the coast to the mountains of North Carolina, but numbers are declining (Partin 1967). The species has probably been declining in numbers since the arrival of settlers from Europe. As mature native forests have been cleared for farmlands and development, or converted to pure Slash and Loblolly pine plantations, numbers of turkeys have likely steadily decreased. Habitat destruction, illegal hunting, free-running dogs, and the introduction of game farm turkeys are cited as major problems (Cherry 1968, Partin 1967). The wild Turkey is a game bird in North Carolina, and its populations are managed by the North Carolina Wildlife Resources Commission. We must, however, maintain a strong concern, for without continued assistance this species will likely become *Threatened or Endangered*.

References: Cherry, T. 1968. Let's not release game farm wild "Turkeys." Wildlife in N. C. 32(2):22-23.
Partin, L. 1967. The vanishing Tarheel. Wildlife in N. C. 31(3): 7, 27.

AVES; GRUIFORMES; RALLIDAE
(Rails, Gallinules, and Coots)

Gallinula chloropus (Linnaeus)
Porphyryula martinica (Linnaeus)

COMMON GALLINULE
PURPLE GALLINULE

Remarks: Both the Common and Purple gallinules breed in freshwater habitats such as old mill ponds, marsh impoundments, or flooded rice fields. Such habitats are generally limited in North Carolina, and consequently populations of both species are low. Should such areas not be maintained, numbers of both species will be expected to decline.

Rallus elegans Audubon

KING RAIL

Remarks: The status of the King rail in North Carolina is uncertain, but it is generally considered to nest in the fresh marshes throughout the state. In coastal regions where such marshes are relatively abundant it is probably present in adequate numbers. In the interior of the state, however, there appears to be a tendency toward the elimination of small marshes, either through draining or the clearing of lake shorelines. This reduction of habitat may result in a restriction of breeding range to coastal regions.

AVES; CHARADRIIFORMES; CHARADRIIDAE
(Plovers)

Charadrius melodus Ord
Charadrius wilsonia Ord

PIPING PLOVER
WILSON'S PLOVER

Remarks: Piping plovers nest very sporadically on North Carolina's beaches. Wilson's plovers are more abundant. Both depend on areas in early stages of succession, generally associated with natural overwash zones or dredge deposits. Both habitats depend on man's activities, and the success of the Wilson's plover, especially, is clearly tied to man's use of the beaches and to the continued dumping of dredge spoil.

AVES; CHARADRIIFORMES; LARIDAE
(Gulls and Terns)

Gelochelidon nilotica (Gmelin)
Larus atricilla Linnaeus
Sterna albifrons Pallas
Sterna hirundo Linnaeus
Thalasseus maximus (Boddaert)
Thalasseus sandvicensis (Latham)

GULL-BILLED TERN
LAUGHING GULL
LEAST TERN
COMMON TERN
ROYAL TERN
SANDWICH TERN

AVES; CHARADRIIFORMES; RYNCHOPIDAE
(Skimmers)

Rynchops niger Linnaeus

BLACK SKIMMER

Remarks: The Laughing gull, terns, and Black skimmer are colonial ground nesters only in estuaries, either on natural beaches, natural islands, or dredge islands. Most have been eliminated from the natural beaches by increased human activity, and all but the Black skimmer and Least tern rely almost completely on man-made dredge islands. Should the deposition of dredge spoil on the coastal islands stop, these sites would progress naturally to shrub thickets not suitable as nesting sites for the above species. In such a situation the numbers of breeding gulls and terns would certainly drop significantly. Current numbers are uncertain, but ongoing research should establish base population levels by 1979.

AVES; STRIGIFORMES; TYTONIDAE
(Barn Owls)

Tyto alba (Scopoli)

BARN OWL

Remarks: Little is known about the past or present status of the Barn owl in North Carolina. The bird is encountered uncommonly and there are few nest records. This is difficult to explain, since this owl is wide-ranging and commonly nests in vacant buildings and other man-made structures. Studies on the current status of this species are being conducted by personnel of the North Carolina State Museum of Natural

History. It is generally believed that Barn owls are declining throughout the United States, and they have been recommended for the "Blue List."

AVES; PICIFORMES; PICIDAE
(Woodpeckers)

Melanerpes erythrocephalus (Linnaeus)

RED-HEADED WOODPECKER

Remarks: According to a report issued 25 April 1975 by the Migratory Bird and Habitat Research Laboratory, Laurel, Maryland, analysis of the Breeding Bird Survey data shows that the Red-headed woodpecker continues to decline in population at the rate of 3% per year in the eastern United States. The North Carolina populations of this bird remain stable throughout most of the Coastal Plain, including the Sandhills. Elsewhere across the state, however, the species appears to be unable to maintain itself at many localities. In the Piedmont the Red-headed woodpecker is now found regularly only in open stands of mature hardwoods in urban and suburban situations like golf courses, parks, and college campuses.

AVES; PASSERIFORMES; HIRUNDINIDAE
(Swallows)

Progne subis (Linnaeus)

PURPLE MARTIN

Remarks: Purple martins depend on man-made houses for nesting sites and are traditionally associated with farm and suburban yards. However, there is an indication that numbers of nesting birds are declining, at least in certain parts of the state. The cause may be suspected to involve pesticides, as martins are aerial insect feeders. Declines are poorly documented, however, and further study is needed.

AVES; PASSERIFORMES; CORVIDAE
(Jays, Magpies, and Crows)

Corvus corax Linnaeus

COMMON RAVEN

Remarks: This species is reasonably common, but apparently not as abundant as it was prior to the 20th century. It is considered of concern because of its rather restricted range, the possibility that it may be declining in North Carolina, and the presumed impact of rock climbing on nesting pairs. W. D. Zeedyk (pers. comm.) claimed that Common ravens nested on Devil's Courthouse prior to completion of the Blue Ridge Parkway and subsequent rock climbing activities. It is most often seen in high mountain habitats, and may be more abundant in and around balds than elsewhere. During the nesting season it is secretive, and consequently its ancestral nesting areas are poorly documented. Cairns (1891) reported nesting in the Craggy Mountains about 1890. A nest with young was found on Grandfather Mountain on 14 April 1940, and a nest was reported on Wayah Bald in April 1932 (Pearson et al. 1959). More recent nesting

has been observed at Silvermine Bald in Pisgah National Forest (USDA Forest Service 1974). The observation of about 85 birds gathered on Black Balsam Mountain near Shining Rock Wilderness, in November 1973 (W. D. Zeedyk, pers. comm.), indicates that this may be an important roost or communal gathering place. According to Hooper (in press), rock ledges with an overhang above and below are preferred as nest sites in Virginia. Nests are occasionally placed in trees, but this appears to be much less prevalent. Hooper et al. (1975) found nesting density to be one pair per 15 square miles in Virginia. The bird may be limited by a general lack of suitable nest sites in North Carolina, unless tree nests are more common here than in Virginia, or it may be limited by food supply. Research is needed to determine population trends and locations of nest sites.

- References: Pearson et al. (1959); see list following introduction.
Cairns, C. J. 1902. List of the birds of Buncombe County, North Carolina. Privately printed. Dated 6 July 1891.
Hooper, R. C. In press. Nesting habitat of Common ravens in Virginia. Wilson Bull.
_____, H. S. Crawford, E. R. Chamberlain, and R. F. Harlow. 1975. Nesting density of the Common raven in the Ridge and Valley region of Virginia. Amer. Birds 29:931-935.
USDA Forest Service. 1974. Raven and Golden eagle observations near Shining Rock Wilderness during 1974. In-service report completed by S. Knickerbocker. U. S. Dept. Agri. Forest Service, Asheville, NC.

AVES; PASSERIFORMES; SITTIDAE
(Nuthatches)

Sitta canadensis Linnaeus

RED-BREASTED NUTHATCH

Remarks: This species occurs in coniferous forests of Canada, the northern United States, and locally in the western mountain ranges. In the eastern United States it breeds in forests of spruce, fir, hemlock, and white pine in the central and southern Appalachian Mountains into North Carolina, where the southern breeding limit occurs. Here it breeds in spruce-fir forests of the Great Smoky, Black, Balsam, and Nantahala mountains, Pisgah Ridge, Grandfather and Roan mountains, and Elk Knob; in hemlock forests of the Great Craggy, Blue Ridge, and Unicoi mountains, and Highlands Plateau; and in white pine forests of the Highlands Plateau. Its former range in North Carolina corresponded with the occurrence of breeding habitats, and at least 90% of the spruce-fir type has been destroyed, resulting in a major constriction of range and a decline in total numbers. Within the required habitat, population density fluctuates irregularly, although the bird is usually fairly common.

AVES; PASSERIFORMES; TURDIDAE
(Thrushes and Bluebirds)

Sialia sialis (Linnaeus)

EASTERN BLUEBIRD

Remarks: Bluebird numbers seem to be up after a serious decline. Part of this success appears to be the result of educational programs and the erection of bluebird houses. Although concern for the species lessens with success of the promotional campaign, we need to realize that conditions could easily return to more unfavorable circumstances.

AVES; PASSERIFORMES; SYLVIIDAE
(Gnatcatchers and Kinglets)

Regulus satrapa Lichtenstein

GOLDEN-CROWNED KINGLET

Remarks: This boreal species is widely distributed in forests of northern conifers and tamarack through Canada and the northern United States, and in the western mountains south to Guatemala. In the eastern United States it breeds locally in forests of spruce, fir, hemlock, and white pine in the central and southern Appalachian Mountains, reaching its southern breeding extremity in North Carolina. Here it breeds in spruce-fir forests of the Great Smoky, Black, Plott Balsam, Balsam, and Nantahala mountains, Pisgah Ridge, Grandfather and Roan mountains, and Elk Knob; in the hemlock forests of the Great Craggy and Blue Ridge mountains and Highlands Plateau; and in white pine forests of the Highlands Plateau. As with the Red-breasted nuthatch, its former distribution in North Carolina corresponded to the occurrence of breeding habitats, and destruction of the spruce-fir type has resulted in a major contraction of total range and a marked decline in total numbers. Within the required habitat, the population is stable and the species is fairly common.

AVES; PASSERIFORMES; LANIIDAE
(Shrikes)

Lanius ludovicianus Linnaeus

LOGGERHEAD SHRIKE

Remarks: The Loggerhead shrike is an uncommon to fairly common permanent resident throughout North Carolina, usually more abundant in the Piedmont than elsewhere. During the breeding season the species is rare or absent at higher elevations in the mountains and in the north-eastern Coastal Plain counties. Shrikes are good indicators of general environmental conditions because they feed upon a wide variety of small animals, including snakes, insects, rodents, and songbirds. There is some evidence that local shrike populations are sharply reduced following certain types of agricultural spraying. The situation, however, needs further investigation.

AVES; PASSERIFORMES; PARULIDAE
(Wood Warblers)

Dendroica petechia (Linnaeus)

YELLOW WARBLER

Remarks: Yellow warblers nest in the Piedmont and mountains of North Carolina. Some workers suspect that numbers are decreasing, possibly due to clearing of pond and streamside willow thickets, the preferred nesting habitat. Further documentation of this apparent decline is needed.

Dendroica virens (Gmelin)

BLACK-THROATED GREEN WARBLER

Remarks: The race *D. v. waynei* is an uncommon and local breeding bird in the Coastal Plain of North Carolina. It is restricted to hardwood and cypress swamps. Continued loss of nesting habitat is occurring, and populations are likely declining.

Helminthophila (=Limothlypis) swainsonii (Audubon)
Protonotaria citrea (Boddaert)

SWAINSON'S WARBLER
PROTHONOTARY WARBLER

Remarks: Prothonotary and Swainson's warblers live almost exclusively along the floodplains in eastern North Carolina. Both species depend on the continued presence of extensive floodplain forests. If channelization or swampland forest clearing increase, populations of both will undoubtedly decline.

AVES; PASSERIFORMES; FRINGILLIDAE
(Grosbeaks, Finches, Sparrows, and Buntings)

Ammospiza (=Passerherbulus) henslowii (Audubon)

HENSLOW'S SPARROW

Remarks: Although there are several records of Henslow's sparrow at scattered localities in North Carolina, no active breeding populations are presently known for the state. Because of the scarcity of proper nesting habitat (wet meadows) and the secretive behavior of the birds, the present breeding status in the state is uncertain.

Passerculus sandwichensis (Gmelin)

"IPSWICH" SPARROW

Remarks: The rare and interesting subspecies, *P. s. princeps*, was until recently considered a distinct species. It breeds only on a narrow, 27 km (17 mi.) stretch of Sable Island off Nova Scotia, and winters along the Atlantic coast from Massachusetts to southern Georgia. It is rare in North Carolina in spite of extensive areas of beach habitat. It has more rigid habitat requirements than do other races of the Savannah sparrow, and what optimum habitat exists is being pervaded by various human activities.

The following species are considered to be of status *Undetermined*. The reasons for their placement in this category are provided in remarks.

AVES; CICONIIFORMES; ARDEIDAE
(Heron and Bitterns)

Botaurus lentiginosus (Rackett)

AMERICAN BITTERN

Remarks: This bird is fairly common in North Carolina in winter, but rare or absent in summer. It has nested in North Carolina at least once. If it still nests in the state, its habitat may be threatened by loss of marshland. More information on its nesting status is needed.

AVES; FALCONIFORMES; ACCIPITRIDAE
(Hawks and Harriers)

Buteo platypterus (Vieillot)

BROAD-WINGED HAWK

Remarks: This hawk is decreasing in some parts of the United States, and its nesting status in North Carolina is largely unknown.

Circus cyaneus (Linnaeus)

MARSH HAWK

Remarks: This is a fairly common species in coastal North Carolina in winter, and throughout the rest of the state during migrations. There is one positive nesting record from Hyde County, and several recent summer records in eastern Carteret County suggest the possibility of its also nesting elsewhere in the state.

Elanoides forficatus (Linnaeus)

SWALLOW-TAILED KITE

Remarks: The Swallow-tailed kite is primarily an occasional late spring to early summer visitor to North Carolina. It is thought to have nested here in the early 1900's, and recent evidence suggests that it may currently nest in the Buxton Woods area, Hatteras Island. If so, its habitat is probably threatened. More information on the nesting status of this species in North Carolina is needed.

Ictinia mississippiensis (Wilson)

MISSISSIPPI KITE

Remarks: The Mississippi kite is an occasional summer visitor to the coastal areas of North Carolina, but there is some evidence that it may nest along the Pee Dee River in Anson County. If it does, draining of swamp forests could be a major threat. More information is needed.

AVES; GRUIFORMES; RALLIDAE
(Rails, Gallinules, and Coots)

Coturnicops noveboracensis (Gmelin)

YELLOW RAIL

Remarks: Because of its extremely secretive nature, the status of this rail is largely unknown. However, the few records seem to

of Red-cockaded woodpeckers. The local race may be declining, perhaps as a result of forest fire prevention. In view of its scarcity, we recommend that holders of scientific collecting permits be prohibited from taking this bird on breeding grounds in the state until a study can be conducted to determine whether or not *S. v. appalachiensis* is a threatened or endangered race.

AVES; PASSERIFORMES; TYRANNIDAE
(Tyrant Flycatchers)

Empidonax alnorum (Brewster)

ALDER FLYCATCHER

Empidonax traillii (Audubon)

WILLOW FLYCATCHER

Remarks: Both of these birds are also known as Traill's flycatcher. The Willow flycatcher (song: *fitz-bew*) breeds southward in the southern Appalachian Mountains to Rabun County, Georgia, and at scattered localities in the North Carolina Piedmont eastward to Raleigh. The Alder flycatcher (song: *fee-bee-o*) was heard singing in a bog at Price Park near Blowing Rock, North Carolina, during the summers of 1972 and 1974, and this site is presumed to be the present southern limit of breeding for the species. Peripheral species can be greatly reduced or locally extirpated by relatively small changes in their chosen habitats. The Willow flycatcher nesting site at North Wilkesboro has already been destroyed. An attempt should be made to preserve the remaining known or suspected breeding sites of these flycatchers in North Carolina until biologists can investigate the extent and significance of their recently discovered range extensions.

AVES; PASSERIFORMES; TURDIDAE
(Thrushes and Bluebirds)

Catharus (=Hylocichla) ustulatus (Nuttall)

SWAINSON'S THRUSH

Remarks: The only breeding record of this bird for North Carolina is from Craggy Mountain, 20 May 1896. Because no summer records for it have been recorded in the past 75 years, it is presumed to be only a migrant through the state. However, since field work has not been done in many parts of the mountains, and since it is known to nest at Mt. Rogers, Virginia, just north of our border, its breeding status in the state is somewhat uncertain.

AVES; PASSERIFORMES; PARULIDAE
(Wood Warblers)

Helmitheros (=Limnothlypis) vermicivorus (Gmelin)

WORM-EATING WARBLER

Remarks: The status of this bird as a breeding bird in the Coastal Plain is unclear. In the mountains it is considered an uncommon to fairly common breeder, and in the Piedmont it is apparently absent from most sections. Recent sightings of territorial males in northeast Tyrrell, northwest Dare, western Gates (near the Chowan River), and Carteret

indicate that it is an uncommon winter resident in the higher marshes (not regularly flooded by tides) and low meadows along the coast. Higher marshes are more likely to be altered by human activities, and the Yellow rail's habitat may be threatened. More information pertaining to its abundance and habitat preference is needed.

Laterallus jamaicensis (Gmelin)

BLACK RAIL

Remarks: This is another extremely secretive species whose exact status is unknown. It formerly bred in low meadows in the Coastal Plain and Piedmont sections of North Carolina, but it appears that today most or all of the former inland breeding localities have been destroyed by human activities. It probably no longer breeds in inland North Carolina. The species has recently been found along the coast in summer and is assumed to breed there. The limited information so far available suggests that it breeds only in the higher marshes and is of local occurrence. More information, especially on the nesting status, is needed.

AVES; CUCULIFORMES; CUCULIDAE
(Cuckoos)

Coccyzus erythrophthalmus (Wilson)

BLACK-BILLED CUCKOO

Remarks: Stupka (1963) called the Black-billed Cuckoo a "fairly common summer resident . . . present in approximately the same numbers as its yellow-billed cousin." Field work by several experienced observers indicates that it is at best uncommon in the mountains of North Carolina. One committee member hiked approximately 150 miles through prime habitat in two recent summers and heard the call of the Black-billed cuckoo only four times. The species formerly bred at least sparingly in the Piedmont and northern Coastal Plain, but now it appears to be only a rare transient in these regions of the state. Breeding season reports from states to the north of us suggest that the Black-billed cuckoo population is declining throughout its range. Some effort should be made to determine whether or not it is in danger of extirpation at the southern limit of its breeding distribution.

Reference: Stupka, A. 1963. Notes on the birds of Great Smoky Mountains National Park. Univ. Tennessee Press, Knoxville, TN. p. 66.

AVES; PICIFORMES; PICIDAE
(Woodpeckers)

Sphyrapicus varius (Linnaeus)

YELLOW-BELLIED SAPSUCKER

Remarks: The race of the Yellow-bellied sapsucker nesting above 1,050 meters (3,500 feet) in the mountains of North Carolina, *S. v. appalachiensis*, is very uncommon and highly localized in distribution, as is usually the case with avian forms breeding at the periphery of their range. Nests are ordinarily near openings in mature groves of deciduous trees, mainly in fire-scarred areas. Breeding pairs of these birds are undoubtedly far less numerous in the state than breeding pairs

(Croatan National Forest) counties, suggest a possible breeding population in the Coastal Plain. More summer field work is needed before the true status of the species can be ascertained.

Mniotilta varia (Linnaeus)

BLACK-AND-WHITE WARBLER

Remarks: During the past several years summer records of this bird have been made at various localities throughout the Coastal Plain. Since its breeding range has previously been described as the mountains and Piedmont, the eastern limits of this range need to be investigated.

AVES; PASSERIFORMES; ICTERIDAE
(Meadowlarks, Blackbirds, and Orioles)

Icterus galbula (Linnaeus)

NORTHERN ORIOLE

Remarks: This bird was formerly known as the Baltimore oriole. Despite the fact that Pearson et al. (1959) described the Northern oriole as "not an uncommon summer resident west of the Blue Ridge," breeding populations are quite local, with one of the largest occurring along the New River system in Ashe County. This area is threatened by impoundment. The fact that a pair of Northern orioles has nested two consecutive years in Winston-Salem also raises the question of its breeding status outside the mountains. Further work on range and extent of populations is needed.

Reference: Pearson et al. (1959); see list following introduction.

AVES; PASSERIFORMES; FRINGILLIDAE
(Grosbeaks, Finches, Sparrows, and Buntings)

Loxia curvirostra Linnaeus

RED CROSSBILL

Remarks: The Red crossbill nests in the North Carolina mountains southward at least to the Great Smoky Mountains National Park and Highlands. Evidence of breeding also exists from Wake and Moore counties, and recent summer records from other places suggest the possibility of widespread nesting along the fall line. Specimens collected in North Carolina have been assigned to four different races, and some individuals taken in the Great Smokies are reported to have characters unlike any described race. The three specimens taken by Sykes in Wake County in 1967 to establish evidence of local breeding are assignable to *L. c. bentii*, the race recognized as breeding in the Rocky Mountains and the western edge of the Great Plains. In North Carolina the Red crossbill may be giving ornithologists an opportunity to simultaneously monitor the development of one new subspecies in the mountains and another along the fall line. Certainly the situation demands careful observation and thorough documentation.

Poocetes gramineus (Gmelin)

VESPER SPARROW

Remarks: This bird breeds southward in the Appalachian Mountains to Buncombe and Haywood Counties, and possibly to Great Smoky Mountains National Park. It formerly bred, probably casually or accidentally, eastward to Greensboro and Rocky Mount. This is another species that must be studied before its status as a breeding bird here can be determined.

Spinus pinus (Wilson)

PINE SISKIN

Remarks: Although no firm evidence of breeding has yet been obtained from North Carolina, Pine siskins are found throughout the year at elevations above 1,440 meters (4,800 feet) in the mountains, and may very well nest there. This is one of several species whose breeding status in the Canadian Zone spruce-fir forest needs further investigation

Discussion

Tom Quay: Approximately how many of the nesting species are on your concern list, and what percentage is this of the total nesting fauna of the state? About how many nesting birds are there in the state?

Parnell: That is a good question. Is Eloise Potter here? Eloise, what does the total North Carolina list look like now?

Eloise Potter: Right at 400 species occur in North Carolina, and about 225 nest here.

Parnell: Then looking at all categories, we are talking about 35% of the entire breeding bird fauna.

Quay: Fifty to eighty out of two-hundred and twenty-five, that's a pretty high percentage, isn't it?

Parnell: It is. But again, remember we are talking only about the situation in North Carolina. Many of these are more common elsewhere. Our list may be refined downward somewhat, or upward somewhat, of course, as we get better information.

Helen Allen: Has the development on Smith Island endangered any of the nesting bird species yet?

Parnell: No, I think not. Smith Island is a very interesting area. It wasn't a particularly important nesting area for any threatened or endangered group of North Carolina birds. It's more important as a migratory stopover for several of them. Peregrine falcons and Brown pelicans do use the beaches there in the fall, but they do not nest in that area.

Bill Butcher: I was very encouraged this summer to read in the *Progressive Farmer* of a farmer who had been convinced by a county agent to leave a stand of timber that some Red-cockaded woodpeckers had been sighted in. I was wondering, in following the theme of what we can do or what somebody can do, can we not use publications like the *North Carolina Agricultural Review* and *Progressive Farmer* to pin-point areas where farmers or landowners can leave stands of timber or leave habitat and not necessarily harvest them?

Parnell: As Dr. Hardin mentioned, the educational process will be the most important single thing that can come out of this kind of conference. We are apparently going to attempt to legislate, but if we legislate without first thoroughly educating the public, we're going to fail. The legislation is going to be in the nature of a restrictive kind of legislation, and if you do not have public sympathy, then it is going to fail.

Frank Barick: In response to this point about the Red-cockaded Woodpecker, the group might be interested to know that the North Carolina Wildlife Resources Commission is enlisting the assistance of the hunters of North Carolina this year and in the next few years in locating

colonies of Red-cockadedads. Hopefully we will find several of these colonies over the state and provide the people who own the land with information on how to preserve them. The North Carolina Wildlife Federation is going to put on quite a campaign on this and we are looking for good positive results.

Susan Bondurant: In reference to Smith Island and Bald Head Island, I think it is important that we remember that a change in an area adjacent to a nesting habitat can sometimes have a deleterious effect on the nesting habitat, and the mentioning of Smith Island did make me remember the White ibis nesting on Battery Island. While the corporation down there proposes to leave Battery Island as a preserve, the ensuing boat ferry traffic projected for future development of that island could very well disturb those wary birds and cause them to leave and nest elsewhere, and I don't know where else they might go. I think we need to bear that in mind when looking at similar areas.

Parnell: This kind of thing is always important. Human usage of any area, whether direct or indirect, is important. I think in that particular case increased boat traffic would not affect Battery Island.

Herb Hendrickson: Do we run into any problems with threatened species by limitation of wintering habitat? Not on breeding birds for this state but those that winter here.

Parnell: That is a very good question -- possibly so. Generally speaking, the breeding habitats appear more critical. On the other hand, again generally speaking, we know much less about the birds in the winter time. I think in most cases we just do not have the kind of information to really answer the question.

Quay: Eloise Potter, you have been Editor of the *Chat*, the bulletin of the Carolina Bird Club, for 12 years. There are 1500 members of the Carolina Bird Club and I don't think anybody has contributed more in so many ways than you have for over 12 years. Do you have any comments at all?

Potter: Thank you, Tom. I have been thrilled by this meeting. I feel as if our Bird Committee has done a big job in getting ready to go to work in the way that we have wanted to approach the problem of learning more about the endangered and threatened species in North Carolina. I hope in the process we will learn more about all of our birds.

Quay: I think we will.

Chris Marsh: In reference to the question about the wintering birds, I think the committee decided, or at least it was my understanding, that wintering populations and other species migrating through the state were not considered unless there was some sort of pressure put upon them while they were in the state. Such birds, say, as the Henslow's sparrow that winters sporadically in broomsedge fields in the state were not considered because there did not seem to be any pressure acting upon them here. One bird that we did decide to include was the Merlin because there was a

pressure as it migrated through the state. Falconers still trap them illegally on the Outer Banks. So, as of now I don't think the wintering populations or those birds migrating through the state should be considered.

Barry Thomas: Dr. Parnell, do you think, from what you found out about the Black duck, that it should be taken off the hunting list and placed with the Canvasback and the Red-head?

Parnell: I don't really have the background, Barry, to have a positive opinion on that. I think that generally waterfowl are being very carefully looked at by both the U. S. Fish and Wildlife Service and by state wildlife interests. The fact that they are showing some serious concerns about such species indicates that that interest is certainly continuing. The take of Black ducks has been constantly restricted in recent years, and this encourages me to believe that the interest of the bird is being looked after. I do not have enough of a professional opinion about that species to hazard a specific valid opinion.

Quay: Where is Stuart Critcher? Does he have an opinion? Frank?

Barick: The opinion, of course, that those of us who work for the Commission have, is that, as Jim has already indicated, all of the waterfowl species, all of those that are on the hunting list, are under intensive surveillance by the U. S. Fish and Wildlife Service and the individual states. Should it become necessary or desirable to take them off the hunting list, why of course they will be taken off the list. The point system and season length determinations are mechanisms which are used to ensure the preservation of these species. And I think that you can be pretty sure that, should it develop that a species needs more protection, then it will get it.

Parnell: We generally know much more about waterfowl, in terms of numbers and status, than almost any of the other species on the list. We do not have the same kind of professional input and concern for the non-game species that we have generally had for the game species.

Mammals

Introduction

by

David S. Lee and John B. Funderburg

There are at least 75 species of terrestrial mammals known from North Carolina. This is a respectable number. In fact, it is the largest state mammal fauna along the east coast. If we included marine mammals, it would probably be the largest in the country, certainly in eastern United States. It is the sincere hope of the Mammal Committee that this diversity can be maintained. The knowledge that certain native species still inhabit a particular place enhances that place, and in our minds the character of the land and its aesthetic and other values are greatly increased.

Some of the more conspicuous elements of our mammal heritage have already been lost. The last Buffalo disappeared from North Carolina in the 1760's, and is the first species of animal or plant known to be extirpated from the state. It has left behind only its name, which is shared by about 50 scattered features and sites. This animal was apparently still common in the late 1720's when Colonel William Byrd surveyed the line which now separates North Carolina and Virginia, for he noted its presence several times in his journals. There is also historical documentation of numbers of Buffalo in the 1750's, but by 1765 John Bartram reported that "the buffaloe, once so very numerous, is not at this day to be seen in this part of the country". All he mentioned were the remains of a Buffalo lick, and seeing "heaps of the white, gnawed bones of the ancient buffaloe".

Other major mammals followed the Buffalo. The Elk was extirpated by hunting pressure, disappearing by the late 1700's. The Gray Wolf could still be found in the more remote sections of the state until the late 1890's and early 1900's, and there is even one report of a wolf killed as recently as 1933. The mountain and Piedmont populations of the White-tailed deer were totally hunted out by the beginning of this century, and the last native Beaver was apparently trapped in 1897. Later, deer and beaver were both reintroduced. There is some reason to suspect that the Porcupine and Fisher once occurred in the mountainous portions of North Carolina, but their presence in historic times cannot be substantiated.

The loss of these species, and the potential loss of some of those discussed in the pages that follow, should be viewed as something more than the obvious decline of species diversity. As variety decreases we move toward an orderly but comparatively monotonous uniformity. Extirpation pursued to its extreme would leave us with a handful of introduced species, and a few native forms with wide ecological tolerances. In the past much of man's extermination of animals seemed inevitable and even desirable. Today, however, with growing respect for environmental ethics, many would no longer agree that an increase in deer herds is adequate compensation for the decline of the Mountain Lion or extermination of the Elk and Buffalo. Furthermore, extirpation of the Elk, Buffalo, and Gray Wolf represents more than a decline of faunal diversity or aesthetics. It is an important if immeasurable loss to the integrity of the whole ecosystem. Even some of our extant species now survive in such modest

numbers, like the Manatee, or are managed at densities so far below the potential carrying capacity of the available habitat, like the Black Bear, that they contribute very little to their environments as populations.

We have prepared the following lists and accounts with the hope of preventing the extirpation of populations of other native mammals. Our work should be considered tentative, since we do not currently have the necessary data to substantiate assignment of many of our mammals to more precise categories. It is almost embarrassing to expose our present lack of information concerning the status of mammals in North Carolina. For most species the documented distributions are spotty, and much of this information is based on old records. We know even less about relative densities. This is partly because mammals as a group are more difficult to study than other vertebrates. The major problem, however, is that North Carolina non-game species have received little attention. It is difficult to evaluate the status of populations when we have such limited base-line information. Perhaps the greatest contribution of this report, indeed this entire Symposium, will be to bring attention to these gaps in our knowledge.

A brief review of the literature may serve to illustrate the paucity of local information. The earliest organized account of North Carolina mammals was C. S. Brimley's 32-page "A Descriptive Catalogue of the Mammals of North Carolina, Exclusive of the Cetacea". The publication date for this account was 1905, but it actually did not appear until March, 1908. It was revised and updated from 1944 to 1946 as a series of 18 installments in *Carolina Tips* and included the cetaceans. During the years between these efforts the only major paper published was "The Mammals of the Great Smoky Mountains," by Edwin and Roy Komarek (1938). Most of the records in this paper were from Tennessee, but some data on North Carolina were included. Since this time a fair number of papers dealing with the montane mammals has appeared, and a list is provided later.

In 1942 and 1952 some attention was specifically focused on coastal mammals when Engels wrote on the fauna of Ocracoke Island southwest of Hatteras, and Shackleford Banks off Beaufort, two of North Carolina's famed Outer Banks. Smith, Funderburg, and Quay provided an updated but still incomplete checklist of the state's mammals in 1960. Various elements of our fauna have been included in taxonomic revisions of specific groups (e.g. Hall and Cockrum 1953), general publications (e.g. Hall and Kelson 1959), and separate papers (e.g. Paradiso 1959), but the only additional regional paper to appear was a 1965 summary of records for marine mammals occurring from Cape Hatteras to Georgia, by Caldwell and Golley. The North Carolina State Museum of Natural History is preparing a comprehensive book on mammals of the state, but publication is a number of years in the future.

All of the species herein considered *Endangered* are also currently considered endangered on the national level, and it is primarily on this basis that we have afforded them such status. Other species must certainly qualify for placement in this category, but we are not able to include them at this time.

The Northern Flying Squirrel, the single species listed here as *Threatened*, is the only local mammal that occupies a small geographic area, is confined to a specialized habitat, and for which we can document a decline in range. Habitat alteration, combined with direct ecological competition from a close relative, creates a real threat to this form.

The Black Bear has been placed in the category of *Special Concern*. Its range and numbers have certainly declined in historic times, but because of regulations and management practices of the North Carolina Wildlife Resources Commission we do not believe the bear to be in immediate danger of extirpation.

Our list of species whose status is *Undetermined* is quite substantial. The main reason for this is our decision to limit other categories to those species for which we had ample justification. All of the *Undetermined* species are rare. Several are probably threatened with extirpation, but we cannot document this possibility. As has been explained to the point of redundancy, much field work remains to be done before a more accurate list can be prepared.

Many species of "northern" mammals reach the southern limits of their distributions in the southern Appalachians. Some are limited to small, isolated, boreal plant communities; others seem less ecologically restricted, yet are still uncommon. The Northern Flying Squirrel, and 14 of our 22 terrestrial *Undetermined* species, are confined or nearly confined to the mountainous sections of the state. The relict spruce-fir forests and associated ecotonal communities of the Appalachians provide the only habitat for some mammals, and major areas of abundance for others. A few of these species, like the Red-backed Vole, Smoky Shrew, and Red Squirrel, are known to be quite abundant at higher elevations and are of no concern in our current context. Others, however, remain seemingly uncommon or rare, even in areas of optimum habitat, and many have spotty distributions. Mammals in this second group are discussed in the pages that follow. Studies of the mammal fauna of the North Carolina portions of the southern Appalachians are comparatively extensive and include Conaway and Howell (1953), Handley (1971), Komarek and Komarek (1938), Johnston (1967), Linzey and Linzey (1968, 1971, 1973), Odum (1949), Smith et al. (1974), and Whitaker et al. (1975). Although our knowledge of mountain mammal distributions and abundance is far from complete, it is certainly the most intensively studied area of the state. A species-by-species investigation of status *Undetermined* mammals of the Appalachians will probably reveal that many are indeed the rare relicts we believe them to be, and that some deserve to be listed in more critical categories.

Our knowledge of many North Carolina bats is sparse. We have included 9 of our 15 species in the following lists, but suspect that some may be relatively common but not usually encountered. The Indiana *Myotis* is considered *Endangered* throughout its range, but its real status in North Carolina is unknown. We assume that there are no major wintering populations in the state, but there is a possibility that summer colonies may be rather widespread in the mountains. Biological exploration of North Carolina's caves in winter, a difficult task, is needed and planned.

All marine mammals except the federally *Endangered* Manatee are listed as status *Undetermined*, and are discussed briefly in pages 407 and 408.

Five of the mammals listed in this report are of concern only on the subspecies level. Other populations of the same species in the state are not believed to be in danger. Three of these, *Sorex longirostris fisheri*, *Blarina brevicauda telmalestes*, and *Microtus pennsylvanicus nigrans*, are Dismal Swamp endemics. Both the Dismal Swamp subspecies and the Appalachian subspecies of the Southern Bog Lemming are listed. A southeastern race of the Wood Rat which enters North Carolina only in the extreme

southeastern corner of the state, and an undetermined race of the Fox Squirrel restricted to a few counties in the southwestern mountains, are also listed as *Undetermined*. With these exceptions all mammals mentioned in this report are of concern on the species level, although we have identified state populations subspecifically when possible.

Protecting the habitats of North Carolina's rare mammals is a valid strategy for maintaining populations. However, land acquisition and *laissez faire* policies alone may not be sufficient to perpetuate many of the terrestrial species discussed in this report. Some of the peripheral forms display very narrow ecological tolerances and often occur only in ecotonal habitats. These and other species associated with unstable seral stages of plant community succession may need careful management if viable populations are to be maintained (Lee and Cooper 1976). Many of our rare species *appear* to be safe because they occur in National Parks, National Forests, and other areas that are relatively free from development. This apparent security may ultimately become a problem if the effects of natural shifts in the communities, and encroaching competition from close relatives or ecological equivalents, remain unknown. Although it is beyond the scope of this Symposium, we highly recommend research to provide possible guidance in instituting active management programs for these rare animals.

We would like to thank all the members of the Mammal Committee, whose knowledge provided the basis of this report: Fred Barkalow, Joe Boyette, Howard Campbell, John Collins, Joe Hamilton, Don Harke, Gwilym Jones, and Peter Weigl. Their addresses can be found elsewhere in this volume. The authors of specific accounts are indicated at the end of each. The account of the Water Shrew by Gwilym Jones appears in abbreviated form. Fred Barkalow provided much useful information on the Mountain Lion.

The following persons kindly surveyed their respective collections and files and provided records of North Carolina mammals: Sydney Anderson, American Museum of Natural History; Donald P. Christian, Michigan State University; Peter Dalby, University of Virginia; Donald H. DeFoe, Great Smoky Mountains National Park; Navar L. Elliott, Charlotte Nature Museum; Robert D. Fisher, National Fish and Wildlife Laboratory, National Museum of Natural History; Lawrence R. Heaney, Museum of Natural History, University of Kansas; Emmet T. Hooper, University of Michigan; Samuel F. Howe, Academy of Natural Sciences of Philadelphia; J. C. Howell and Michael R. Pelton, University of Tennessee; Robert Izor, Field Museum of Natural History, Chicago; Ralph Jordan, Tennessee Valley Authority; M. Edith Rutzmoser, Museum of Comparative Zoology, Harvard University; Ben Sanders, U. S. Forest Service, Asheville; Duane A. Schlitter, Carnegie Museum of Natural History, Pittsburgh; Richard Stout, Schiele Museum of Natural History, Charlotte; and Merlin Tuttle, Milwaukee Public Museum. Steve Platania and Chris Marsh, student research associates at the North Carolina State Museum of Natural History, helped compile specimen records, and Barbara B. Lee, Associate Curator, assisted in preparing the manuscript.

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Species List

Species	Status
Insectivora	
Soricidae	
<i>Blarina brevicauda telmalestes</i> , Dismal Swamp	
Short-tailed Shrew 402	Undetermined
<i>Microsorex hoyi winnemana</i> , Pygmy Shrew 402	Undetermined
<i>Sorex dispar blitchi</i> , Long-tailed Shrew 403	Undetermined
<i>Sorex longirostris fisheri</i> , Dismal Swamp	
Southeastern Shrew 403	Undetermined
<i>Sorex palustris punctulatus</i> , Water Shrew 403	Undetermined
Talpidae	
<i>Parascalops breweri</i> , Hairy-tailed Mole 403	Undetermined
Chiroptera	
Vespertilionidae	
<i>Lasiurus seminolus</i> , Seminole Bat 403	Undetermined
<i>Myotis austroriparius austroriparius</i> , Southeastern Myotis 404	Undetermined
<i>Myotis grisescens</i> , Gray Myotis 404	Undetermined
<i>Myotis keenii septentrionalis</i> , Keen's Myotis 404	Undetermined
<i>Myotis leibii leibii</i> , Small-footed Myotis 404	Undetermined
<i>Myotis lucifugus lucifugus</i> , Little Brown Myotis 404	Undetermined
<i>Myotis sodalis</i> , Indiana Myotis 392	Endangered
<i>Plecotus rafinesquii macrotis</i> , Rafinesque's Big-eared Bat 404	Undetermined
Molossidae	
<i>Tadarida brasiliensis cynocephala</i> , Brazilian Free-tailed Bat 405	Undetermined
Lagomorpha	
Leporidae	
<i>Lepus americanus virginianus</i> , Snowshoe Hare 405	Undetermined
<i>Sylvilagus transitionalis</i> , New England Cottontail 405	Undetermined
Rodentia	
Sciuridae	
<i>Glaucomys sabrinus coloratus</i> , Northern Flying Squirrel 398	Threatened
<i>Sciurus niger</i> , Eastern Fox Squirrel (mountain population) 405	Undetermined
Castoridae	
<i>Castor canadensis</i> , Beaver	Extirpated (Reintroduced)
Cricetidae	
<i>Microtus chrotorrhinus carolinensis</i> , Rock Vole 406	Undetermined

Cricetidae (cont'd)

<i>Microtus pennsylvanicus nigrans</i> , Dismal Swamp Meadow Vole 406	Undetermined
<i>Neotoma floridana floridana</i> , Eastern Woodrat 406	Undetermined
<i>Synaptomys cooperi helaletes</i> , <i>S. c. stonei</i> , Southern Bog Lemming 406	Undetermined

Erethizontidae

<i>Erethizon dorsatum</i> , Porcupine	Extirpated (former status uncertain)
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Carnivora

Ursidae

<i>Ursus americanus</i> , Black Bear 400	Special Concern
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Mustelidae

<i>Martes pennanti</i> , Fisher	Extirpated (former status uncertain)
<i>Mustela nivalis allegheniensis</i> , Least Weasel 406	Undetermined

Canidae

<i>Canis lupus</i> , Gray Wolf	Extirpated
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Felidae

<i>Felis concolor</i> , Mountain Lion or Panther 394	Endangered
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Artiodactyla

Cervidae

<i>Cervis canadensis</i> , Elk	Extirpated
<i>Odocoileus virginianus</i> , White-tailed Deer	Nearly Extirpated; Reintroduced)

Bovidae

<i>Bison bison</i> , Buffalo or Bison	Extirpated
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Sirenia

Trichechidae

<i>Trichechus manatus</i> , Florida Manatee 396	Endangered
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See pages 407 and 408 for other marine mammals.

SPECIES ACCOUNTS

MAMMALIA; CHIROPTERA; VESPERTILIONIDAE
(Vespertilionid Bats)

Myotis sodalis Miller and Allen

INDIANA MYOTIS

Description: A medium-sized bat with dark gray, or brown to light brown, fur, not glossy. The base of each hair is black for over two-thirds of its length, followed by a narrow grayish band which is not sharply delimited from the black base. The tips of the hairs may be dark gray to black, or dark to light brown. The nose is pink. Hairs on the foot are short and inconspicuous. The calcar, a cartilage support in the outer edge of the "tail membrane," is strongly keeled. Barbour and Davis (1969) provide keys to identification (pp. 13-22) and illustrations (pp. 88, 92-94, Plate IX).

Distribution: Range -- midwest and E United States, from W edge of Ozark region in Oklahoma to central Vermont, to S Wisconsin, south to N Alabama. One apparently vagrant specimen from N Florida. Greatest winter concentration in caves of N Kentucky, and winter distribution associated with major cavernous limestone areas. Limits of summer distribution are unknown.

North Carolina -- mountains (5 localities); few caves here offer suitable habitat, and no major hibernacula or nursery sites known. No attempt yet made to determine summer distribution.

Habitat and Mode of Life: Like other vespertilionid bats, *M. sodalis* is a nocturnal predator of flying insects. In winter it hibernates in large clusters in caves. The microenvironmental requirements at this time are very specific, and only a few known caves seem suitable. Emergence from hibernation occurs in March and April, at which time the bats migrate to summer feeding areas. Steven Humphrey (1974 *viva voce*) indicated that at this time of year they roost in hollow trees, or under dead bark. Feeding occurs at night, in the upper canopy layer above small streams.

Reproduction: Mating takes place in caves in the fall. The few available reproductive data suggest that females produce a single young, in late June.

Status: *Endangered*. The Indiana Myotis is so designated in the federal list. A drastic reduction in numbers has been noted by bat researchers in recent years, and the total current United States population has been estimated at 500,000. Thirty years ago there were caves and mines in New England, New York, and Pennsylvania which harbored hundreds of colonies. Now only occasional individuals can be found throughout most of that area. During the 1950's this bat nearly disappeared from West Virginia, Indiana, and Illinois, and several populations in Missouri have been severely depleted. The causes of these losses are unknown, but a major factor is undoubtedly man's interference. The social habits of the bats make them very vulnerable. Hall (1962) reported that two boys killed

about 10,000 *M. sodalis* in Carter Cave, Kentucky, in a matter of minutes. Disturbance of winter roosts and nursery colonies by cavers and others seeking recreation is increasing. Bat banding programs, rabies studies, collecting of bats to use as experimental animals, and other scientific studies are apparently having an adverse effect. Unless adequate protection is afforded hibernacula, the species will probably disappear within a few years. Fortunately, a major colony inhabits Mammoth Cave National Park, where the bats are protected (Barbour and Davis 1969). Since these bats are insectivores, poisoning by insecticides may be partly responsible for their decline.

Densities in North Carolina are unknown but assumed to be low. Only nine specimens are known from the state. Linzey and Linzey (1968), discussing the Tennessee sector of Great Smoky Mountains National Park, stated: "Apparently large numbers of these bats inhabit the Park area." C. E. Mohr counted 2,242 individuals in a cave in this Park on December 3, 1950.

Captive propagation of the species is probably unrealistic. Attempts to breed other vespertilionids in captivity have not been successful.

Recent studies show that many species of bats are rapidly declining in numbers. A major cause is purges of cave colonies. Misguided by overpublicized rabies scares, people have burned, stoned, and clubbed many thousands of dormant bats as they hung from the ceilings of caves. Disturbance and arousal of hibernating bats causes them to use stored fat reserves and starve before spring emergence. Some colonies may temporarily or permanently vacate home caves if persistently annoyed, which forces the resident bats to compete with other colonies or other species for roosts and feeding areas.

Remarks: In the fall of 1963 the American Society of Mammalogists appointed a committee to investigate reductions in bat populations. A resolution approved by the Society on June 17, 1964 made a number of recommendations for conservation, including discouraging removal of bats from caves except for scientific research, and discontinuance of molestation or other unnecessary disturbance of bats in roosts. The National Speleological Society, working through several Task Forces within its Conservation Committee, has for many years been educating its members about the problems associated with bat preservation. This organization supports bat conservation research, and has requested moratoria on caving activities in specific bat sites at critical times of the year.

Other common names for this species include Indiana Bat and Social Bat.

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Authors: John B. Funderburg and David S. Lee.

MAMMALIA; CARNIVORA; FELIDAE
(Cats)

Felis concolor True

MOUNTAIN LION OR PANTHER

Description: A very large, long-tailed cat, attaining a total length of 1.8 to 2.3 m (6 to 7 1/2 ft.), and weights of 45 to 67.5 kg (100 to 150 lb.). Maximum recorded length is around 2.8 m (9 1/3 ft.) and maximum weight around 102 kg (225 lb.). Its short fur is plain brownish, with whitish underparts, and the tip of the tail is conspicuously dark. Cubs are light brown with irregular, brownish black spots. The tracks are large, 9 cm (3.5 in.), and the retractive claws do not show. Those of the front and hind feet often overlap but seldom register. Its route of travel is often direct, whereas bobcats usually travel an irregular or circling path. There are no specimens from North Carolina in collections, thus it is not possible to assign this animal to subspecific status here. It is likely that both *F. c. cougar* Kerr (a northeastern race) and *F. c. coryi* Bangs (a southern race), and/or intergrades, occur here. Illustrations of the adult and tracks are in Burt and Grossenheider (1964, p. 69 and plate opposite).

Distribution: Range -- disjunct in wilderness areas of United States, mostly western; apparently recorded from Arkansas and Louisiana, west to Pacific coast, and Florida. Ranges through Mexico into South America. Once had largest range of any native land mammal, occurring throughout most of western hemisphere, from British Columbia to Patagonia, and from sea level to elevations of 3,300 m (nearly 11,000 feet).

North Carolina -- occurrence here postulated on basis of recent sight records, most from remote sections of Coastal Plain and mountains (see Lee 1977); hair from Gaston Co. Likely to occur in any relatively uninhabited area where deer abound.

Habitat and Mode of Life: This graceful carnivore is a creature of remote, rugged habitats, like mountains, gorges, and swamps. It may be active at any hour, but seems to be chiefly nocturnal. Hornocker (1969) found that females had a home range of 5 to 20 square miles, while the territories of males covered 25 square miles or more. Deer is the main food, and the cats may cover large carcasses with debris, returning later for additional feedings. They take domestic stock infrequently, although individual cats occasionally become problems. They normally shun all contact with humans, and verified attacks are extremely rare.

Reproduction: Females become sexually mature at two to three years of age and breed at two to three year intervals. Males may not become mature until the fourth or fifth year. After a gestation period of 90 days, one to four, usually two, young are born. The young lose their

spotted coat in about six months, but remain with the female for up to two years (Wright 1972). Ten to twelve years seems to be the normal life span of captive individuals.

Status: *Endangered*. This big cat is accorded this status in the federal and IUCN lists. For many years it was believed gone from much of eastern North America, but appears to be making a slow comeback in the southeast. Wright (1972) stated that the total number surviving in eastern North America, exclusive of Florida, may not be more than a hundred, and maybe far fewer. In North Carolina there have always been a modest number of annual reports. Sightings seem to be increasing, both in location and in number (Lee 1977). Barkalow (pers. comm.) obtained the first evidence for the recent occurrence of the Mountain Lion in this state. Hair from a tree in Gaston County has been tentatively identified as that of this species.

This cat's only enemy is man, whose persecution and alteration of habitat drove the eastern populations to the brink of extinction years ago. Since it is a top order carnivore, fecundity is minimal, and recovery will be slow even if adequate protection can be assured. In many ways certain areas of North Carolina are wilder and more remote now than they were at the turn of the century. Vast sections are designated National Forest, and extensive timber management areas exist. Even though the human population of the state has greatly increased, it has not had much direct impact on really wild areas. Combined with the restocking and spectacular comeback of the White-tailed Deer, this is probably a significant factor in the apparent increase of mountain lions in the state.

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Author: David S. Lee.

MAMMALIA; SIRENIA; TRICHECHIDAE
(Manatees)

Trichechus manatus Linnaeus

FLORIDA (WEST INDIAN) MANATEE

Description: The Manatee is a massive, gray to gray brown, thick skinned, and nearly hairless aquatic mammal. Its forelimbs are paddle-like, hind limbs are lacking, and the tail is horizontally flattened. The upper lip is cleft, lobed, and fleshy, with bristles. Maximum recorded weight is 680 kg (1,500 lb.), but average weight is between 360 and 540 kg (793 to 1,190 lb.). The maximum length ranges from 4 to 6 m (13 to 19 1/2 ft.), and average length is 3 m (9 3/4 ft.). Illustrations are in Cahalane (1961, p. 627) and Lowery (1974, pp. 476-480).

Distribution: Range -- coastal North Carolina to Florida Keys and Gulf of Mexico, west to Pensacola and Louisiana coast. Occasional in extreme S coastal Texas. Winters in Florida. Older records exist from Delaware, New Jersey, and Virginia, and it was once more extensive along Texas and Louisiana coasts. Also along Atlantic coasts of Central and South America south to Brazil, and throughout Caribbean Islands to an unknown degree.

North Carolina -- poorly known; occasionally at least as far north as Point Lookout in summer.

Habitat and Mode of Life: Manatees frequent nearshore marine and estuarine habitats, and move up rivers for variable distances. All are herbivorous and of potential importance in energy and nutrient cycling. They may be of value in the control of localized aquatic weeds, but this is untested.

Reproduction: Reproductive habits of the Manatee are poorly known, but fecundity is low. Females produce one calf, possibly at two or three year intervals. Twins are reported rarely and need substantiation. Calves may remain with mothers for several years, and attainment of sexual maturity may require six to eight years.

Status: *Endangered*. The Manatee is considered of this status throughout its range by the federal government, and as *Depleted* by the IUCN. Although no accurate quantitative census is available, populations are obviously low. An estimate based on an aerial survey of winter congregations in Florida suggests a minimum total United States population of perhaps 1,000 individuals. Reports from the 1800's and early 1900's indicate a much larger population, perhaps many thousands. Heavy exploitation for meat appears to have been responsible for the initial decline, and still continues outside the United States. Much Manatee habitat has been lost, particularly to incompatible human uses. The major mortality factor today appears to be injury from boats.

The potential for captive propagation is believed to be low because of low fecundity. Space and food requirements make long term captive maintenance expensive. Only one instance of mating and reproduction in captives is known, at the Miami Seaquarium, Florida, in 1975. There are only seven captive individuals in the United States, all from Florida.

Among other limitations, the Endangered Species Act of 1973 makes it illegal to "harass, harm, pursue, hunt, shoot, wound, kill, trap, or collect" Manatees. While this species now appears to be only an occasional seasonal visitor to North Carolina waters, there is no justification for discounting the importance of local habitats to the species. These will be especially important if protective measures in other areas result in population increases. There is reason to suspect that the present paucity of data on this animal in North Carolina results more from lack of attention than lack of Manatees.

Research on distribution here is critical. Areas of significant Manatee usage should be determined, seasonal presence documented, and migration routes delineated. Steps should be taken to regulate boat traffic in appropriate areas and seasons to minimize the potential for boat kills. At present known densities in North Carolina, a public education campaign may suffice to provide adequate protection. If areas of critical Manatee habitat are located, steps should be taken to prevent their loss.

Remarks: The North Carolina State Museum of Natural History is co-operating with the U. S. Fish and Wildlife Service in a Manatee survey and educational program in coastal North Carolina.

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Author: Howard W. Campbell.

MAMMALIA; RODENTIA; SCIURIDAE
(Squirrels)

Glaucomys sabrinus coloratus Handley

NORTHERN FLYING SQUIRREL

Description: This is a medium-sized squirrel, some 26 to 30.5 cm (10 1/4 to 12 in.) total length and 95 to 140 g (3.4 to 4.9 oz.) in weight. It has a broad, flattened tail, and dense, silky fur. The patagia, folds of skin between front and hind limbs which enable "flying" squirrels to glide, are fully haired from wrist to ankle. The Northern Flying Squirrel can be distinguished from the Southern, *G. volans*, by its larger size (ex. hindfoot 33-41 mm), the gray base of its ventral hairs as opposed to the white base of the southern form, and the short, stout baculum (penis bone) of the males. For a thorough description of the subspecies see Handley (1953), and see Howell (1918) for a generic revision. Walker et al. (1964, p. 720) provides photographs of *G. volans* in flight.

Distribution: Range -- a southern Appalachian subspecies, known from four isolated localities in mountains of North Carolina, Tennessee, and southern Virginia. Former distribution unknown in modern times, but fossil remains indicate larger range during periods of cooler climate.

North Carolina -- Roan Mountain, Mt. Mitchell, and Great Smoky Mountains.

Habitat and Mode of Life: Although usually associated with spruce-fir forests, this form is more often captured in adjacent stands of mature hardwoods (beech, yellow birch, maple, hemlock, red oak, and buckeye). It is generally found at altitudes of 1,200 to 1,830 m (about 4,000 to 6,000 ft.). Unlike its southern counterpart, the Northern Flying Squirrel is less dependent on seeds and nuts for food, and, in fact, may not be able to use the conifer seeds of boreal habitats (Brink 1965). It can apparently subsist on lichens and fungi, but also takes some seeds, buds, fruit, staminate cones, and animal material (McKeever 1960; Weigl 1968). The species apparently lives in family groups of adults and juveniles. In areas which it frequents, it is often possible to trap from two to six individuals within a 300 X 400 m area. Home range encompasses about 2 to 2.5 hectares (4.9 to 6.1 acres). Its gliding locomotion and nocturnal activity are characteristic of the genus.

Reproduction: Little reproductive information is available for the subspecies. Investigators of northern populations mention two litters of two to six young per year, but trapping data from the southern Appalachians suggest a single annual litter. Two captive females each bore four young.

Status: *Threatened*. This is a tentative assignment based on the animal's rarity, island-like distribution, and certain aspects of its ecology. The current numbers of this squirrel are unknown, but some populations, e.g. Mt. Mitchell, seem to be in decline. During the past ten years, as far as can be determined, this rare mammal has only been captured in the Roan Mountain area on the North Carolina-Tennessee line, and Whitetop Mountain, Smyth County, Virginia. Eight weeks of trapping in

1965 and 1966 in the Mt. Mitchell area, where this squirrel had formerly been collected, failed to locate a single individual. No significant range extensions for *G. s. coloratus* have been reported in the literature since it was described by Handley (1953). However, the Northern Flying Squirrel is secretive, difficult to capture, and often confined to relatively inaccessible areas. Thus, populations may remain undetected.

Habitat destruction from clear cutting, certain forest management practices, and recreational development may have adversely affected some populations. Recent research also indicates that *G. sabrinus* may be displaced by the more aggressive *G. volans* in certain hardwood habitats where they overlap. The latter species has been trapped at two localities near areas originally occupied by the former. There is some evidence, too, that the Southern Flying Squirrel harbors a parasitic nematode of the genus *Strongyloides* which may be transferred to the Northern in contact zones, and is lethal or debilitating.

The number in captivity is unknown, but there are eight at Wake Forest University, Winston-Salem. The species tolerates captivity well, and breeding success with other subspecies has been good in the United States and Canada. The southern populations, however, have bred less well in captivity.

Additional research is needed on the Northern Flying Squirrel in the southern parts of its range before precise protective measures can be proposed. Preservation of high elevation forests and bogs, including both spruce-fir stands and adjacent zones of northern hardwood vegetation, is a necessity.

Remarks: The disjunct distribution of this squirrel in North Carolina and its great distance from the center of the species range in the northern United States and Canada suggest that it is a relict form which has become isolated in small patches of suitable habitat by changing climatic and vegetational conditions since the last ice age.

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Author: Peter D. Weigl.

MAMMALIA; CARNIVORA; URSIDAE
(Bears)

Ursus americanus Pallas

BLACK BEAR

Description: A large, bulky mammal with black, brown, or tannish fur. The average adult is 60 to 90 cm (2 to 3 ft.) tall at the shoulder. Males are somewhat larger than females, ranging from 1.5 to 2 m (60 to 79 in.) in length and weighing from 88 to over 225 kg (195 to 500 lb.), although the latter is exceptional. Adult females range from 1.3 to 1.8 m (52 to 69 in.) in length and weigh from 67.5 to 124 kg (150 to 275 lb.). The muzzle is brown, and a small white throat patch is occasionally present. See Wormer (1966), Hall and Kelson (1959, pp. 865-869), and Burt and Grossenheider (1964, Plate opp. p. 37) for further information and illustrations.

Distribution: Range — one subspecies or another is found throughout most of North America, into Mexico; eastern form occurs west to Texas, Montana, and extensively in Canada.

North Carolina — most of present range in Coastal Plain and mountains; formerly statewide.

Habitat and Mode of Life: The most suitable habitat for the Black Bear is undeveloped tracts of woodland with 5,000 or more contiguous acres. In the Coastal Plain it occurs in swamps, woods, and pocosins, and in heavy forests of the mountains. Adults, especially males, may move considerable distances. Food consists of a great variety of plant and animal material, including grasses, berries, roots, invertebrates, small mammals, the young of large mammals, carrion, fish, and even smaller members of its own kind. Bears are usually nocturnal, but may be seen

abroad in daytime, especially in parks. Dens are made in depressions beneath logs, in fractured rock, or similar places. Where winters are prolonged and severe, bears enter a period of torpor which is often referred to as hibernation.

Reproduction: The female Black Bear is physically capable of reproducing at the age of 2 1/2 years, but less than 5% actually reproduce at that age. Breeding generally begins at 3 1/2 years and continues until at least 17 1/2 years of age (Collins 1973). Mating occurs in July. Approximately seven months later one to five cubs (average 2.2), weighing about 226 g (8 oz.) each, are born (Wormer 1966). They remain with the female about 1 1/2 years, during which time she does not breed; thus, a given female breeds only in alternate years.

Status: *Special Concern.* The decline of the Black Bear in North Carolina can be attributed to human encroachment, a continual and accelerating process, especially since the early 1950's. Existing populations are threatened to the extent that their habitat is threatened. Eastern swamps and bays are being cleared, drained, and converted to crop- and timberlands. Habitat in the mountains is being lost to development for summer homes and recreational purposes. The bear population in these areas can be expected to decrease at a rate directly proportional to the increase in habitat destruction.

The Black Bear has long served as an important big game species for sport hunting in eastern United States, and today ranks after the White-tailed Deer and wild Turkey in this respect. North Carolina's populations are monitored by personnel of the Wildlife Resources Commission, which regulates hunting seasons and bag limits as necessary to protect this valuable resource. The total statewide population is approximately 2,000 animals, and there is about 15% annual recruitment. The 26 bear sanctuaries sponsored by the Commission, Great Smoky Mountains National Park, Bladen Lakes State Forest, and the ten eastern counties which are closed to bear hunting, probably support from 500 to 800 bears at present. Some 160 to 200, or 15% of those available for hunting, are harvested annually. In recent years the season has been reduced from 68 to 45 hunting days, and the season bag limit reduced from two animals to one per hunter. It is unlawful to take a female with cubs, or any bear weighing less than 22.5 kg (50 lb.). Mandatory tagging and reporting of kills has been in effect since 1975. The Wildlife Resources Commission initiated a Black Bear study in 1969. Information gathered from analysis of annual harvests and telemetric studies indicates that the percentage of females harvested by hunters may be reduced as a result of a shift in the opening date of the hunting season.

Illegal trapping and killing of bears is still a problem, although more intensive enforcement has resulted in a reduction of such losses during the past several years.

Captive propagation is easily accomplished, if females nearing parturition are isolated from all other bears, especially males. They readily breed in captivity, starting at 2 1/2 years of age, and can be bred on an annual basis if the cubs are removed sometime prior to the mating season (North Carolina Wildlife Resources Commission 1972). There were approximately 40 captive bears in North Carolina in 1975, but this figure

Mammals -- Undetermined

will drop due to recent legislation prohibiting their captivity in the state except under special conditions.

Remarks: The Mayo Clinic is conducting physiological and metabolic studies on black bears during hibernation. Their findings have been significant for hemodialysis procedures in humans, and may prove beneficial in space travel efforts.

References: Burt and Grossenheider (1964), Hall and Kelson (1969); see list following introduction.
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Authors: John M. Collins and Joe Hamilton.

The following mammals are of status *Undetermined*. Reasons for their being of concern are given in the remarks following each species listing.

MAMMALIA; INSECTIVORA; SORICIDAE
(Shrews)

Blarina brevicauda telmalestes (Merriam)

DISMAL SWAMP
SHORT-TAILED SHREW

Remarks: Until recently this animal was thought to be a distinct species, but is now considered a subspecies of the widespread *Blarina brevicauda* (C. O. Handley, pers. comm.). Although common in sites around the Dismal Swamp, it occurs only in a restricted area and must therefore be considered comparatively rare. Portions of its habitat have been lost to draining.

Microsorex hoyi winnemana Preble

PYGMY SHREW

Remarks: This race of the Pygmy Shrew ranges from Baltimore County, Maryland, to southwestern North Carolina, but is rare throughout. It is known from two localities in the North Carolina mountains, and the only specimens were collected in 1928 and 1941. The species is poorly represented in collections everywhere, but this may simply mean that it is not as susceptible to conventional trapping techniques as other shrews.

Sorex dispar blitchi Schwartz

LONG-TAILED SHREW

Remarks: This shrew is rare and locally distributed, with four known localities in Swain and Haywood counties. One of the latter is the type locality. It appears to be restricted to forested, moist, rocky outcroppings and talus slopes above 1,350 m (4,500 ft.) in elevation. Like the other Appalachian species of this genus, it reaches the southern limit of its range in North Carolina and Tennessee.

Sorex longirostris fisheri Merriam

DISMAL SWAMP SOUTHEASTERN SHREW

Remarks: This race of the Southeastern Shrew is found only in the Dismal Swamp region of Virginia and North Carolina. It has been found most frequently in bogs, marshy and swampy thickets, or dense brush in nearby woods. Its abundance in North Carolina, and the exact limits of its range, are unknown. Habitat for the species has been somewhat reduced by draining. The nominate subspecies is relatively common and widespread in North Carolina.

Sorex palustris punctulatus Hooper

WATER SHREW

Remarks: The Water Shrew is known in North Carolina only from the upper reaches of Fires Creek, Clay County. Four specimens were trapped along a 180 m (200 yd.) section of the creek by Gwilym S. Jones in 1973. The precise distribution and abundance of this shrew within the southern Appalachians is unknown.

MAMMALIA; INSECTIVORA; TALPIDAE
(Moles)

Parascalops breweri (Bachman)

HAIRY-TAILED MOLE

Remarks: This is another species that apparently reaches the southern limit of its range in the mountains of North Carolina. Here it is confined to elevations between 900 and 1,920 m (about 3,000 to 6,300 ft.), but in adjacent Tennessee it has been reported down to 450 m (1,500 ft.). The Hairy-tailed Mole seems to prefer damp areas near rhododendron thickets. It has been reported from 16 North Carolina localities. Moles enjoy some protection in North Carolina as a result of regulations passed by the Wildlife Resources Commission on July 21, 1975, aimed at restricting the use of pesticides as a method of control.

MAMMALIA; CHIROPTERA; VESPERTILIONIDAE
(Vespertilionid Bats)

Lasiurus seminolus (Rhoads)

SEMINOLE BAT

Remarks: The Seminole Bat was first discovered in North Carolina

Mammals -- Undetermined

in the mid-1950's, but since that time only a single specimen has been reported, in 1963. The species is known from Johnston, Mecklenburg, Wake (2 collections), and New Hanover (2 collections) counties. All records are from July, August, and September.

Myotis austroriparius austroriparius (Rhoads)

SOUTHEASTERN MYOTIS

Remarks: One specimen of this bat, collected 48 km (30 mi.) above Wilmington on the Cape Fear River in 1953, is the only record from the state. It is assumed to be a vagrant since the range lies well south of this locality.

Myotis grisescens Howell

GRAY MYOTIS

Remarks: One individual of this species banded in Tennessee was recovered in October, 1968, in Asheville, Buncombe County. This locality is outside the known range of the species, and the specimen is assumed to be a vagrant.

On April 28, 1976, *M. grisescens* was added to the federal list of species *Endangered* throughout their range.

Myotis keenii septentrionalis (Trouessart)

KEEN'S MYOTIS

Remarks: Like the other species of this genus, this bat appears to be rare in North Carolina. There is one record from the eastern Piedmont and four from the mountains.

Myotis leibii leibii (Audubon and Bachman)

SMALL-FOOTED MYOTIS

Remarks: This bat reaches the southern limit of its range in the mountains of North Carolina and Tennessee. It has been taken at three North Carolina montane localities, but one record for the Piedmont is questionable. The only recent specimen was collected in Swain County in 1954.

Myotis lucifugus lucifugus (LeConte)

LITTLE BROWN MYOTIS

Remarks: There are only eight records of this species from North Carolina, all but three of them from the mountains. These three are old literature reports, and the specimens are no longer available.

Plecotus rafinesquii macrotis LeConte

RAFINESQUE'S BIG-EARED BAT

Remarks: This species is known from 15 widely scattered localities in the mountains and Coastal Plain of the state.

MAMMALIA; CHIROPTERA; MOLOSSIDAE
(Free-tailed Bats)

Tadarida brasiliensis cynocephala (LeConte) BRAZILIAN FREE-TAILED BAT

Remarks: The recent discovery of the Free-tailed Bat in Wilmington, Hallsboro, Buies Creek, and Fayetteville suggests that it is expanding its range northward along the Atlantic Coastal Plain. It was previously known as far north as Charleston, South Carolina. A concentration of 35 wintering individuals found in Fayetteville in December, 1975, implies that the species is a year-round resident.

MAMMALIA; LAGOMORPHA; LEPORIDAE
(Hares and Rabbits)

Lepus americanus virginianus Harlan SNOWSHOE HARE

Remarks: There are no authentic records for the Snowshoe Hare in North Carolina, although it is known from western Virginia and extreme eastern Tennessee. It is included here only because North Carolina appears to be within its historic range. Occasional rumors of this species in the spruce-fir areas of the state remain unsubstantiated.

Sylvilagus transitionalis (Bangs) NEW ENGLAND COTTONTAIL

Remarks: This rabbit is known in North Carolina from seven specimens, all collected in the mountains. It is easily confused with the Eastern Cottontail, *S. floridanus*, and may be more common than our paucity of records indicates.

MAMMALIA; RODENTIA; SCIURIDAE
(Squirrels)

Sciurus niger (subspecies) Linnaeus FOX SQUIRREL

Remarks: Mountain populations of the Fox Squirrel seem to be disjunct, very localized, and low in density. The one specimen collected from the mountains was taken at Andrews, Cherokee County, in 1947. It does not appear typical of *S. n. niger*, and perhaps most closely resembles *S. n. rufiventer*, a race found throughout the upper Mississippi drainage as far east as eastern Tennessee and southwestern Virginia. Populations in the Coastal Plain and eastern Piedmont are considered to be relatively stable and are presently of no major concern.

Mammals -- Undetermined

MAMMALIA; RODENTIA; CRICETIDAE
(Mice, Rats, Voles, and Lemmings)

Microtus chrotorrhinus carolinensis Komarek

ROCK VOLE

Remarks: This vole is known from two counties in the western part of the state. It is fairly common in the Great Smoky Mountains National Park above 840 m (2,800 ft.), but, judging from collections, seems to be rare or absent from other parts of North Carolina. The type locality is about 9 km (5 mi.) north of Smokemont, Swain County, at an elevation of 960 m (3,200 ft.).

Microtus pennsylvanicus nigrans Rhoads

DISMAL SWAMP MEADOW VOLE

Remarks: This race appears to be limited to the Dismal Swamp region of Virginia and North Carolina. Its abundance and zone and extent of intergradation with other subspecies is unknown. The type locality is at Currituck, Currituck County. Elsewhere in the state the species is common and widespread.

Neotoma floridana floridana (Ord)

EASTERN WOOD RAT

Remarks: This race reaches the northern limit of its distribution on Smith Island, Brunswick County, and is presently known in the state only from this locality. It was apparently common as recently as the 1950's, but despite regular trapping only one specimen has been captured since then. It may be extirpated at this site. The mountain subspecies, *N. f. haematores* and *N. f. magister*, do not seem to be abundant but are widely distributed. We do not consider them to be of particular concern at this time.

Synaptomys cooperi stonei Rhoads
Synaptomys cooperi helaletes Merriam

SOUTHERN BOG LEMMING OR
SOUTHERN LEMMING MOUSE

Remarks: *S. c. helaletes* is a disjunct endemic race found in the Dismal Swamp, and is currently known from only one site in North Carolina. *S. c. stonei* is known from eleven localities in western North Carolina, mostly from higher elevations. The species is not very common in our area and appears to be ecologically confined to a limited number of relict communities.

MAMMALIA; CARNIVORA; MUSTELIDAE
(Weasels and Relatives)

Mustela nivalis allegheniensis (Rhoads)

LEAST WEASEL

Remarks: This is another montane species that reaches the southern limit of its distribution in North Carolina and Tennessee. It is known to date from only four North Carolina localities.

Marine Mammals

The Manatee, *Trichechus manatus*, has already been listed and discussed as an *Endangered* species. The status of the remaining marine forms as they relate to North Carolina is less clear. A few are relatively common here, others appear to occur less frequently, and some must be only vagrants. Seals seem to belong in this latter group and perhaps should not be considered under any status of concern. We have chosen, however, to list all the marine mammals as species of *Undetermined* status. This will at least emphasize how little we know about their seasonal occurrences and abundance here. Bottlenose Dolphins are observed commonly off the Atlantic coast and are included only because there is no base-line information on former or present numbers.

The following cetaceans and pinnipeds are known from North Carolina waters, either from being stranded on beaches or observed in waters off the coast. This list does not include all the marine forms that probably occur in our area. Cetacean taxonomy is still apparently in a state of some confusion; the scientific and common names in this list were compiled from Burt and Grossenheider (1964), Hall and Kelson (1959), and Hershkovitz (1966). To the best of our knowledge, only those species marked by an asterisk (*) are not verified by museum specimens.

<i>Balaenoptera borealis</i> Lesson	SEI WHALE OR RORQUAL
<i>Balaenoptera (Sibbaldus) musculus</i> (Linnaeus)	BLUE WHALE
<i>Balaenoptera physalus</i> Linnaeus	FINBACK WHALE
<i>Delphinus delphis delphis</i> Linnaeus	COMMON OR ATLANTIC DOLPHIN
<i>Eubalaena glacialis glacialis</i> Müller	ATLANTIC RIGHT WHALE
<i>Globicephala macrorhyncha</i> (Rice)	SHORT-FINNED BLACKFISH
<i>Globicephala melaena melaena</i> (Traill)	COMMON OR ATLANTIC BLACKFISH
<i>Grampus griseus</i> G. Cuvier	GRAMPUS OR RISSO'S DOLPHIN
<i>Kogia breviceps</i> (Blainville)	PYGMY SPERM WHALE
<i>Kogia simus</i> (Owen)	DWARF SPERM WHALE
<i>Megaptera novaeangliae</i> (Borowski)	HUMPBACK WHALE
<i>Mesoplodon densirostris</i> (Blainville)	ATLANTIC BEAKED WHALE
<i>Mesoplodon europaeus</i> Gervais (= <i>M. gervaisi</i> (Deslongchamps))	GERVAIS' BEAKED WHALE
<i>Mesoplodon mirus</i> True	TRUE'S BEAKED WHALE
<i>Orcinus orca</i> Linnaeus	ATLANTIC KILLER WHALE
<i>Phocoena phocoena</i> Linnaeus	ATLANTIC HARBOR PORPOISE
<i>Physeter catodon</i> Linnaeus	SPERM WHALE
<i>Pseudorca crassidens</i> Owen	FALSE KILLER WHALE
<i>Stenella ceruleoalbus</i> Meyer	STRIPED DOLPHIN
* <i>Stenella frontalis</i> G. Cuvier	CUVIER DOLPHIN
<i>Stenella longirostris</i> (Gray)	SPINNER DOLPHIN
<i>Stenella plagiodon</i> (Cope)	SPOTTED DOLPHIN
* <i>Steno bradanensis</i> Lesson	ROUGH-TOOTHED OR LONGBEAK DOLPHIN
<i>Tursiops truncatus truncatus</i> (Montagu)	ATLANTIC BOTTLENOSE DOLPHIN
* <i>Ziphius cavirostris</i> G. Cuvier	GOOSEBEAK OR CUVIER'S BEAKED WHALE

Mammals -- Marine Mammals

Cystophora cristata (Erxleben)

HOODED SEAL

Phoca vitulina concolor DeKay

HARBOR SEAL

Remarks: The Blue, Finback, Humpback, Atlantic Right, Sei, and Sperm Whale are all considered to be *Endangered* throughout their ranges by the federal government (see Federal Register 40(188):44419, September 26, 1975).

References: Burt and Grossenheider (1964), Hall and Kelson (1959); see list following introduction.
Hershkovitz, P. 1966. Catalog of Living Whales. U. S. Nat. Mus. Bull. 246, Washington, DC. 259 pages.

Cluster Areas

by

Robert P. Teulings and John E. Cooper

One of the objectives of the 1975 Symposium was to attempt to identify areas where groups of species of concern occur in North Carolina. These were termed *Cluster Areas*. They are not to be confused with areas of endemicity, although some of the regions and sites identified as Cluster Areas, like Lake Waccamaw, Waterrock Knob, and the Neuse River, do have numbers of endemic species.

The Cluster Areas which follow are based on an analysis of the lists and accounts presented in all chapters, plus some additional information from the files of the North Carolina State Museum of Natural History and the North Carolina Natural Heritage Program. Our criteria for choosing Cluster Areas were necessarily rather arbitrary. We tried to limit our selections to reasonably discrete "units" containing at least several species of concern, but soon found that, with the available information, this was not possible in very many cases. Thus, the Cluster Areas range in size from general regions like the Outer Banks, and entire river systems and mountain ranges, through more circumscribed sites like Grandfather Mountain and Roan Mountain, to more specific localities like Lake Waccamaw and Umstead State Park. The analysis, therefore, is a preliminary and sketchy effort, whose purpose is to indicate some areas where further investigation would likely reveal particular and protectable sites containing groups of species of concern. The subject is itself worthy of a complete symposium.

Many of the areas noted as sites of cluster are already on public lands, where the job of multi-species protection at sub-sites should ostensibly present little difficulty. Some are at least partially owned by private conservation minded groups and individuals who are already making an effort to prevent harm from coming to the biota on these lands.

The information on clustering is presented in the form of annotated lists of areas and their species, and the notes provided will enable further breakdown by the interested reader in most cases. Although no attempt has been made to specifically correlate cluster with major habitat types (i.e. pocosin, heath bald, spruce-fir forest, etc.), the notes will also allow some additional analysis of this nature.

In the listings, Ex = *Extirpated*; E = *Endangered*; T = *Threatened*; Dep = *Depleted* (used for marine fishes only); SC = *Special Concern*; and U = *Undetermined* (indicating some concern for the species on the part of knowledgeable biologists, but insufficient data for a more precise designation of status).

We would like to thank Alvin L. Braswell, David S. Lee, and William M. Palmer, North Carolina State Museum of Natural History, and Charles Roe, North Carolina Natural Heritage Program, for providing certain information for this chapter.

COASTAL PLAIN

Outer Banks and Adjacent Environs

- Ex? *Acipenser brevirostrum*, Shortnose sturgeon. Anadromous.
Albemarle and Pamlico Sounds.
- E *Lilaeopsis carolinensis*, Carolina lilaeopsis. Freshwater aquatic. Cape Hatteras National Seashore; Buxton Woods.
Caretta caretta caretta, Atlantic Loggerhead.
Chelonia mydas mydas, Atlantic Green Turtle.
Dermochelys coriacea coriacea, Atlantic Leatherback.
Eretmochelys imbricata imbricata, Atlantic Hawksbill.
Lepidochelys kempi, Atlantic Ridley.
All of these large turtles are marine and estuarine forms found in offshore waters. The Atlantic Loggerhead not uncommonly nests on our shores, usually south and west of Cape Lookout. The Atlantic Leatherback nested on one occasion at Cape Lookout.
Falco peregrinus, Peregrine falcon. Major migration route and minor wintering area.
Pelecanus occidentalis, Brown pelican. Nesting.
Trichechus manatus, Manatee. Marine. North to Currituck Sound.
- T *Calamovilfa brevipilis*, Riverbank sandreed. Carteret County opposite Bogue Banks.
- SC *Busycon canaliculatum*, Channeled Whelk.
Busycon carica, Knobbed Whelk.
Busycon contrarium, Lightning Whelk.
All three are marine and estuarine species. Albemarle and Pamlico Sounds.
Evorthodus lyricus, Lyre goby. Marine. Pamlico Sound.
Lampropeltis getulus sticticeps, Outer Banks Kingsnake. Intra-capes zone, between Capes Lookout and Hatteras.
Charadrius melodus, Piping plover. Nesting.
Charadrius wilsonia, Wilson's plover. Nesting.
Gelochelidon nilotica, Gull-billed tern. Nesting.
Hydranassa tricolor, Louisiana heron. Nesting.
Nyctanassa violacea, Yellow-crowned night heron. Nesting.
Nycticorax nycticorax, Black-crowned night heron. Nesting.
Passerculus sandwichensis, "Ipswich" sparrow. Wintering.
Sterna albifrons, Least tern. Nesting.
Sterna hirundo, Common tern. Nesting.
Thalasseus maximus, Royal tern. Nesting.
Thalasseus sandvicensis, Sandwich tern. Nesting.
Tyto alba, Barn owl. Nesting.
Acipenser oxyrhynchus, Atlantic sturgeon. Anadromous.
Albemarle and Pamlico Sounds. (Dep in *Marine Fishes*).
- Dep *Alosa aestivalis*, Blueback herring.
Alosa pseudoharengus, Alewife.

Cluster Areas -- Coastal Plain

Alosa sapidissima, American shad.

All three are anadromous species. Albemarle and Pamlico Sounds.

- U *Natrix sipedon williamengelsi*, Carolina Salt Marsh Snake.
Islands and mainland between Core and Pamlico Sounds.
Elanoides forficatus, Swallow-tailed kite. Hatteras Island;
may be nesting in Buxton Woods.

Great Dismal Swamp

The Great Dismal Swamp occupies part of the North Carolina Coastal Plain above Albemarle Sound.

- E *Lilaeopsis carolinensis*, Carolina lilaeopsis. Marshes and shallow ponds.
- T *Calamovilfa brevipilis*, Riverbank sandreed. Pocosins, savannahs, and bogs.
Buteo lineatus, Red-shouldered hawk. Resident.
- SC *Anas rubripes*, Black duck.
Dendroica virens, Black-throated green warbler. Nesting.
Helminthophila (=Limnodynastes) swainsonii, Swainson's warbler.
Meleagris gallopavo, Turkey. Nesting.
Pandion haliaetus, Osprey.
Protonotaria citrea, Prothonotary warbler. Nesting.
Ursus americanus, Black Bear. Swamps and woodlands.
- U *Blarina brevicauda telmalestes*, Dismal Swamp Short-tailed Shrew. Endemic race; considered a species until recently.
Microtus pennsylvanicus nigrans, Dismal Swamp Meadow Vole.
Endemic race; type locality at Currituck, Currituck County.
Sorex longirostris fisheri, Dismal Swamp Southeastern Shrew.
Endemic race; bogs, thickets, dense brush in woods.
Synaptomys cooperi helaletes, Dismal Swamp Southern Bog Lemming. Disjunct endemic race, known from only one site in North Carolina.
Plecotus rafinesquii macrotis, Rafinesque's Big-eared Bat.

Croatan National Forest and Environs

- E *Arenaria godfreyi*, Godfrey's sandwort.
Asplenium heteroresiliens, Carolina spleenwort fern.
Cystopteris X tennesseensis, Tennessee bladder fern.
All three of these plants occur on marl substrates, Island Creek Natural Area.
Lysimachia asperulaefolia, Rough-leaf loosestrife. Bogs and savannahs south of Newport.
Solidago verna, Spring-flowering goldenrod. Savannahs and pocosins, eastern edge of Forest.

Cluster Areas -- Coastal Plain

Alligator mississippiensis, American Alligator. Lake Ellis, and other bodies of water.

Crotalus adamanteus, Eastern Diamondback Rattlesnake. Pine and evergreen flatwoods, dense bogs, pocosins; northern periphery of range.

Dendrocopos borealis, Red-cockaded woodpecker. Open pine habitats support a significant population.

- T *Calamovilfa brevipilis*, Riverbank sandreed. Bogs and savannahs south of Newport.
 Carex chapmanii, Chapman's sedge. Swampy woods west of Cherry Point.
 Dionaea muscipula, Venus' fly-trap. Savannah and open bog areas at several sites.
 Habenaria flava, Southern rein-orchid. Camp Bryan on Lake Ellis.
 Myriophyllum laxum, Loose watermilfoil. Aquatic. Lake Ellis and Patsy Pond Natural Area.
 Utricularia olivacea, Dwarf bladderwort. Aquatic. Patsy Pond Natural Area.
 Accipiter cooperi, Cooper's hawk.
 Aimophila aestivalis, Bachman's sparrow. Open savannah habitats.
 Anhinga anhinga, Anhinga. Nests at Lake Ellis, northern limit of range.
 Buteo lineatus, Red-shouldered hawk.
 Cathartes aura, Turkey vulture.
 Coragyps atratus, Black vulture.
 Both of these vultures nest at sites in the Forest.
 Phalacrocorax auritus floridanus, Double-crested cormorant.
 Nests at Lake Ellis, northern limit of range.

- SC *Buteo jamaicensis*, Red-tailed hawk.
 Pandion haliaetus, Osprey. Nests at Lake Ellis.
 Ursus americanus, Black Bear. Swamps and pocosins.

- U *Elanoides forficatus*, Swallow-tailed kite.

A major site of cluster within this area is obviously Lake Ellis and associated Camp Bryan. At least six species of concern occur in and around the lake, and there are probably others. This site is essentially in private ownership, and strict wildlife protection measures are in effect there.

Camp Lejeune Marine Base, Holly Shelter, and Vicinity

The Camp Lejeune Marine Base is located in southeastern Onslow County, and Holly Shelter in western Pender County.

- E *Kalmia cuneata*, White wicky. Pocosin ecotones.
 Lysimachia asperulaefolia, Rough-leaf loosestrife. Savannahs.

Cluster Areas -- Coastal Plain

Both plants occur at Holly Shelter.

Alligator mississippiensis, American Alligator. Several bodies of water at Camp Lejeune.

Caretta caretta caretta, Atlantic Loggerhead. Nests on beaches at Camp Lejeune.

Crotalus adamanteus, Eastern Diamondback Rattlesnake. Camp Lejeune and Holly Shelter.

Dendrocopos borealis, Red-cockaded woodpecker. Nesting at Camp Lejeune.

T *Calamovilfa brevipilis*, Riverbank sandreed.

Habenaria integra, Yellow fringeless orchid.

Sarracenia rubra, Sweet pitcher plant.

Sporobolus teretifolius, Wireleaf dropseed.

Trillium pusillum var. *pusillum*, Carolina trillium.

All five plants occur in pocosins, savannahs, pine barrens, and/or swamps in the general region of Maple Hill and Haw.

Dionaea muscipula, Venus' fly-trap. Open bog habitats at Holly Shelter.

Pandion haliaetus, Osprey. Nesting at Camp Lejeune.

SC *Ursus americanus*, Black Bear. Holly Shelter.

Southeastern Coastal Corner

The region extending from just north of Wilmington south to Smith Island, New Hanover County, and the Southport and Long Beach areas, Brunswick County, contains quite a number of species of concern.

Ex? *Taphius eucosmius eucosmius*, Greenfield Ramshorn. Greenfield Pond, Wilmington; endemic.

E *Cystopteris X tennesseensis*, Tennessee bladder fern. Limestone outcrops north of Wilmington.

Lilaeopsis carolinensis, Carolina lilaeopsis. Orton Plantation area; a swamp at Brunswick Town Historical Site; Southport, Long Beach area.

Solidago pulchra, Carolina goldenrod. Savannahs in Wilmington area; Southport, Long Beach area.

Solidago verna, Spring-flowering goldenrod. East of Castle Hayne.

Alligator mississippiensis, American Alligator. Wilmington harbor; Orton Pond.

Crotalus adamanteus, Eastern Diamondback Rattlesnake. Orton Plantation; near Southport.

Haliaeetus leucocephalus, Bald eagle.

T *Dionaea muscipula*, Venus' fly-trap. Edge of pocosins in Wilmington area; Orton Plantation; Carolina Beach State Park; Southport, Long Beach area.

Myriophyllum laxum, Loose watermilfoil.

Utricularia olivacea, Dwarf bladderwort.

Cluster Areas -- Coastal Plain

- Both plants are aquatics; Sunny Point Army Terminal near Brunswick Town Historical Site.
Sarracenia rubra, Sweet pitcher plant. Orton Plantation; Southport, Long Beach area.
Sporobolus teretifolius, Wireleaf dropseed. Orton Plantation; Southport, Long Beach area.
Helisoma magnificum, Cape Fear Ramshorn. Greenfield Pond, Wilmington (endemic?); may also occur in Orton Pond.
Problema bulenta, Rare Skipper. Marshes of general area.
Aimophila aestivalis, Bachman's sparrow. Pine savannahs.
Anhinga anhinga, Anhinga. Nesting resident, Orton Pond.
- SC *Rana areolata capito*, Carolina Gopher Frog. Wilmington area; Carolina Beach; Orton Plantation; Southport.
 Micrurus fulvius fulvius, Eastern Coral Snake. Several localities in dry, pine flatwoods and sandhills habitats.
 Gelochelidon nilotica, Gull-billed tern.
 Pandion haliaetus, Osprey. Nests at Orton Pond.
 Rallus elegans, King rail.
 Sterna albifrons, Least tern.
 Sterna hirundo, Common tern.
 Thalasseus maximus, Royal tern.
 Thalasseus sandvicensis, Sandwich tern.
- U ?*Elliptio* sp., File Spike. May occur in Orton Pond.
 Lasiurus seminolus, Seminole Bat. Two records, New Hanover County.
 Tadarida brasiliensis cynocephala, Brazilian Free-tailed Bat. Wilmington.
 Neotoma floridana floridana, Eastern Woodrat. Northern limit at Smith Island; may be extirpated.

Lake Waccamaw and Environs

At least 17 species of concern, including a number of endemics, occur in and around Lake Waccamaw in eastern Columbus County.

- E *Amnicola* sp., Waccamaw Snail. May be endemic in the lake.
 Elliptio waccamawensis, Waccamaw Spike. Endemic.
 "*Lampsilis*" *radiata* complex, Waccamaw Mucket. Endemic.
 Lioplax subcarinata, Waccamaw Scavenger. Only population known in North Carolina.
 Etheostoma perlongum, Waccamaw darter. Endemic.
 Fundulus waccamensis, Waccamaw killifish. One of only two known sites (the other is Phelps Lake).
 Menidia extensa, Waccamaw silverside. Endemic.
 Alligator mississippiensis, American Alligator. Waccamaw River.
- T *Ilex amelanchier*, Sarvis holly. Cypress swamps along Waccamaw River.
 Elliptio sp., Waccamaw Lance. Endemic.

Cluster Areas -- Coastal Plain

Triodopsis soelneri, Waccamaw Helix. A terrestrial snail, endemic in cypress swamps and piney woods between the Lumber and Cape Fear rivers.
Procambarus (Ortmannicus) lepidodactylus, PeeDee Lotic Crayfish. Canal off Waccamaw River (only definite North Carolina site).

- SC "*Lampsilis*" *ochracea*, Tidewater Mucket.
 Dendroica virens, Black-throated green warbler.
 Protonotaria citrea, Prothonotary warbler.
- U *Elliptio* sp., File Spike.
 Tadarida brasiliensis cynocephala, Brazilian Free-tailed Bat.

Bladen Lakes State Forest and Vicinity

This Forest is located in northeastern Bladen County.

- E *Asplenium heteroresiliens*, Carolina spleenwort fern.
 Kalmia cuneata, White wicky. Jones Lake and Singletary Lake areas.
 Lindera melissaefolia, Southern spicebush.
 Solidago verna, Spring-flowering goldenrod. Pocosins and pine savannahs, White Lake area.
 Dendrocopos borealis, Red-cockaded woodpecker. Resident in several colonies; small breeding populations believed to be in suitable pinewoods habitats in Jones Lake and Singletary Lake State Parks.
- T *Dionaea muscipula*, Venus' fly-trap. Savannahs and open bog margins. Jones Lake, Singletary Lake, White Lake areas.
 Eupatorium resinosum, Resinous joe-pie-weed.
 Hexastylis lewisii, Lewis' heart leaf.
 Sporobolus teretifolius, Wireleaf dropseed.
 Hyla andersoni, Pine Barrens Treefrog.
 Cathartes aura, Turkey vulture.
 Coragyps atratus, Black vulture.
- SC *Rana areolata capito*, Carolina Gopher Frog.
 Micrurus fulvius fulvius, Eastern Coral Snake.
 Ursus americanus, Black Bear.

The Sandhills

The general area known as the Sandhills is characterized by xeric conditions, deep, open sands, and floral communities dominated by longleaf pine, turkey oak, and wiregrass.

- E *Kalmia cuneata*, White wicky.
 Lindera melissaefolia, Southern spicebush. Swamps and pond margins. Lake Upchurch area.

Cluster Areas -- Coastal Plain

- Lysimachia asperulaefolia*, Rough-leaf loosestrife.
Pyridanthera barbulata var. *brevifolia*, Wells' pyxie moss.
 A few localities in Harnett, Moore, and Hoke counties, including Fort Bragg Military Reservation.
Solidago verna, Spring-flowering goldenrod. Mountain Creek southeast of Montrose.
Dendrocopos borealis, Red-cockaded woodpecker. The longleaf pine forests of the Sandhills harbor the state's largest population. Sandhills Game Management Area; Fort Bragg Military Reservation.
- T *Calamovilfa brevipilis*, Riverbank sandreed.
Dionaea muscipula, Venus' fly-trap.
Eupatorium resinosum, Resinous joe-pie-weed.
Sarracenia rubra, Sweet pitcher plant. Mountain Creek southeast of Montrose; Lake Upchurch area; Sandhills Game Management Area; Fort Bragg Military Reservation.
Aimophila aestivalis, Bachman's sparrow. Fort Bragg Military Reservation.
Hyla andersoni, Pine Barrens Treefrog. Sandhills Game Management Area; Fort Bragg Military Reservation.
- SC *Callophrys* (=Mitoura) *hesseli*, Hessel's Hairstreak. White cedar habitats. Southern Pines area; Fort Bragg Military Reservation.
Rana areolata capito, Carolina Gopher Frog.
Micrurus fulvius fulvius, Eastern Coral Snake. Sandhills Game Management Area; Fort Bragg Military Reservation.
Melanerpes erythrocephalus, Red-headed woodpecker.

Chowan River System

- Ex? *Acipenser brevirostrum*, Shortnose sturgeon. Anadromous. Tidal portions of basin.
- SC "Lampsilis" *ochracea*, Tidewater Mucket. Tidal portions. *Orconectes virginianensis*, Chowan River Crayfish. Tributaries.
- Dep *Alosa aestivalis*, Blueback herring.
Alosa pseudoharengus, Alewife.
Alosa sapidissima, American shad.
 All three are anadromous fishes which migrate throughout the Chowan River and tributaries.
Acipenser oxyrinchus, Atlantic sturgeon. Anadromous. Tidal portions of the basin.
- U *Ligumia nasuta*, Eastern Pondmussel. Tidal portions. Only known site of occurrence in North Carolina.

Tar - Pamlico River System

- E *"Canthyria" sp.*, Tar River Spiny Mussel. Endemic. Probably occurs throughout the Tar.
- SC *Elliptio (lanceolata?)*, Yellow Lance. Name currently applied to North Carolina populations of an *Elliptio* which is causing some taxonomic confusion (see Fuller's account in chapter on *Freshwater and Terrestrial Mollusks*).
 "Lampsilis" ochracea, Tidewater Mucket. Upper Coastal Plain portions.
 Ambloplites cavifrons, Roanoke bass. Also Piedmont sections.
 Lampetra aepyptera, Least brook lamprey.
 Noturus furiosus, Carolina madtom. Also Piedmont sections.
 Necturus lewisi, Neuse River Waterdog. Endemic in Tar and Neuse. Also Piedmont sections.
- Dep *Acipenser oxyrinchus*, Atlantic sturgeon. Probably once common in tidal portions, now rare in Pamlico Sound.
 Alosa aestivalis, Blueback herring.
 Alosa pseudoharengus, Alewife.
 Alosa sapidissima, American shad.
 All three are anadromous fishes. The Blueback herring is found only in the lower tidal portions, the Alewife is fairly widely distributed throughout the coastal sections, and the American shad ascends to the Fall Line during spawning runs.

Neuse River System

- Ex? *Acipenser brevirostrum*, Shortnose sturgeon. Anadromous.
 Once ascended Neuse at least as far as New Bern for spawning.
- Notropis bifrenatus*, Bridle shiner. Tucker Creek in lower Neuse drainage was a known locality.
- E *?Carunculina pulla*, Savannah Shoremussel. Presence in Neuse currently unverified.
 Prolasmidonta heterodon, Ancient Floater.
- SC *Ambloplites cavifrons*, Roanoke bass. Coastal Plain of Johnston County; also in Piedmont sections of system.
 Lampetra aepyptera, Least brook lamprey. Specific records from eastern Wake County and eastern Jones County, thus probably throughout coastal Neuse.
 Noturus furiosus, Carolina madtom. Endemic in Neuse and Tar. Also in Piedmont sections.
 Necturus lewisi, Neuse River Waterdog. Endemic in Neuse and Tar. Also in Piedmont sections.
- Dep *Acipenser oxyrinchus*, Atlantic sturgeon. Anadromous.
 Once ascended Neuse as far as New Bern.

Cluster Areas -- Coastal Plain

Alosa aestivalis, Blueback herring.

Alosa pseudoharengus, Alewife.

Alosa sapidissima, American shad.

All three are anadromous fishes; comments about their distributions in the Tar also apply in the Neuse.

Cape Fear River System

E *Elliptio marsupiobesa*, Cape Fear Spike. Endemic. Near Fayetteville.

Alligator mississippiensis, American Alligator. Lower portions.

Trichechus manatus, Manatee. Reports from river mouth.

T *Fusconaia masoni*, Atlantic Pigtoe. Near Fayetteville.

SC *Alasmodonta varicosa*, Brook Floater. Near Fayetteville.

Anodonta couperiana, Barrel Floater. Basin.

Anodonta implicata, Alewife Floater. Upper basin.

Dormitator maculatus, Fat sleeper.

Eleotris pisonis, Spinycheek sleeper.

Both of these fishes occur in the lower reaches near Southport.

Hybopsis n. sp. II, an undescribed chub.

Notropis mekistocholas, Cape Fear shiner. Occurs on both sides of Fall Line.

Noturus n. sp., an undescribed madtom.

Dep *Acipenser oxyrhynchus*, Atlantic sturgeon. Anadromous. Once ascended to at least southeastern Bladen County.

Alosa aestivalis, Blueback herring.

Alosa pseudoharengus, Alewife.

Alosa sapidissima, American shad.

All three are anadromous fishes. See remarks under Tar River.

Lumber River System

T *Procambarus (Ortmannicus) lepidodactylus*, PeeDee Lotic Crayfish. Occurs in tributaries of PeeDee, Black, and Wateree rivers in South Carolina, and may occur here.

SC *Etheostoma mariae*, Pinewoods darter.

Hybopsis n. sp. II, an undescribed chub. Also in Cape Fear.

Noturus n. sp., an undescribed madtom. Also in Cape Fear.

Semotilus n. sp., an undescribed chub.

All of the above fishes are species of tributary streams in the Lumber system.

PIEDMONT PLATEAU

Few definite Cluster Areas can be identified in this province, which may be more reflective of limited knowledge than actuality. Although most of the flora seems to be well catalogued, much of the Piedmont fauna is rather poorly known as far as precise distribution and status are concerned.

Creedmoor-Butner-Providence Area

This area is located in southern Granville County and immediately adjacent Wake County.

- E *Dendrocopos borealis*, Red-cockaded woodpecker. One of but a few known Piedmont sites is located in the Falls Reservoir project area.
- T *Echinacea laevigata*, Smooth coneflower. Meadows and woodlands. Central Granville County and perhaps elsewhere.
Hexastylis lewisii, Lewis' heart leaf. Dry, acid woods and pine forests. Camp Butner.
Panax quinquefolium, Ginseng. Rich woods. Two localities in Falls Reservoir project area.
Accipiter cooperi, Cooper's hawk.
Buteo lineatus, Red-shouldered hawk.
- SC *Buteo jamaicensis*, Red-tailed hawk.
Meleagris gallopavo, Turkey. Still relatively common in area.
- U *Buteo platypterus*, Broad-winged hawk.

Eno River Area

This area extends from western Durham County to central Orange County, in the general vicinity of the Eno River.

- T *Echinacea laevigata*, Smooth coneflower.
Habenaria peramoena, Purple fringeless-orchid. Occoneechee Mountain south of Hillsborough; Eno River valley.
Panax quinquefolium, Ginseng. Bernheim Tract, Eno River State Park.
Rhus michauxii, Michaux sumac. Near Efland.
Accipiter cooperi, Cooper's hawk. Eno River State Park.
Accipiter striatus, Sharp-shinned hawk. Eno River valley.

Umstead State Park.

This State Park is located in western Wake County.

- T *Hexastylis lewisii*, Lewis' heart leaf.

Cluster Areas -- Piedmont Plateau

Panax quinquefolium, Ginseng.
Aimophila aestivalis, Bachman's sparrow. Small population
in marginal habitat (?) at edge of airport runway.
Cathartes aura, Turkey vulture.
Coragyps atratus, Black vulture.

SC *Meleagris gallopavo*, Turkey.

Uwharrie National Forest and Vicinity

Most of the area under consideration here lies in northern and western Montgomery County and adjacent northern and central Stanly County.

- E *Plantago cordata*, Heart-leaf plantain. Slate-bottom streams and swampy woods.
Dendrocopos borealis, Red-cockaded woodpecker. A small population occurs in short-leaf pine in the western section of the Forest.
Felis concolor, Mountain Lion or Panther. Quite a number of reasonable reports come from the Forest.
- T *Habenaria flava*, Southern rein-orchid. Alluvial woods.
Helianthus schweinitzii, Schweinitz' sunflower. Woodlands and meadows.
Nestronia umbellula, Nestronia. Dry woodlands.
Buteo lineatus, Red-shouldered hawk.
- SC *Anillinis* n. sp. B, an undescribed carabid beetle. Along Uwharrie River near Ophir, Montgomery County.
Buteo jamaicensis, Red-tailed hawk.
Dendroica virens, Black-throated green warbler.
Meleagris gallopavo, Turkey.
Protonotaria citrea, Prothonotary warbler.
- U *Hemidactylium scutatum*, Four-toed Salamander.
Buteo platypterus, Broad-winged hawk.

Hanging Rock State Park and Vicinity

This Park lies in central Stokes County in the western Piedmont.

- E *Geum geniculatum*, Bent avens.
- T *Panax quinquefolium*, Ginseng. Northwest of Germantown.
Saxifraga careyana, Carey saxifrage.
- SC *Ambystoma talpoidum*, Mole Salamander.

Neuse River System

- SC *Ambloplites cavifrons*, Roanoke bass.
 Etheostoma collis, Carolina darter.
 Noturus furiosus, Carolina madtom.
 Necturus lewisi, Neuse River Waterdog.

Tar River System

- E "Canthyria" sp., Tar River Spiny Mussel. Endemic.
- SC *Ambloplites cavifrons*, Roanoke bass.
 Noturus furiosus, Carolina madtom.
 Necturus lewisi, Neuse River Waterdog.

Cape Fear River System

- E *Carunculina pulla*, Savannah Shoremussel. May be extir-
 pated; last reported from near Chapel Hill, Orange
 County.
- SC *Etheostoma collis*, Carolina darter.
 Notropis mekistocholas, Cape Fear shiner. Both sides of
 Fall Line, but most abundant in Piedmont.

Dan River System

- T *Noturus gilberti*, Orangefin madtom.
- SC *Etheostoma podostemone*, Riverweed darter.
 Exoglossum maxillingua, Cutlips minnow.
 Hypentelium roanokense, Roanoke hog sucker.
 Moxostoma valenciennianum, Bigeye jumprock.

BLUE RIDGE

New River Watershed (Non-aquatic Species)

In the general New River watershed of Ashe and Watauga counties, especially on some of the mountains of the area, occur 16 species of concern.

- E *Carex misera*, Wretched sedge. Balds and rocky crevices.
 Bluff Mountain.
 Carex purpurifera, Purple sedge. Rich woods. North slope
 of Phoenix Mountain.
 Geum radiatum, Spreading avens. Rocky balds. Bluff Mountain.
 Saxifraga caroliniana, Carolina saxifrage. Rocky seepage
 slopes. Along North Fork of New River.

Cluster Areas -- Blue Ridge

- T *Cymophyllus fraseri*, Fraser's sedge. Rich woods and stream beds. Long Hope Valley, northern Watauga County.
 Lilium grayi, Gray's lily. Balds and meadows. Bluff Mountain; spruce bog on Long Hope Creek; several localities north of Boone, including Rich Mountain.
 Prenanthes roanensis, Roan rattlesnakeroot. Mount Jefferson State Park.
 Saxifraga careyana, Carey saxifrage. Deciduous forests. Along South Fork of New River.
 Vireo gilvus, Warbling vireo. Most recent breeding records from New River area.
- SC *Brachypanorpa carolinensis*, Shortnosed Scorpionfly. Mount Jefferson State Park.
 Dixioria dactylifera, a milliped. Three Top Mountain just north of Bluff Mountain; Mount Jefferson State Park.
 Ursus americanus, Black Bear.
- U *Buteo platypterus*, Broad-winged hawk.
 Empidonax alnorum, Alder flycatcher.
 Icterus galbula, Northern oriole. Largest breeding population in the state recorded along New River in Ashe County.
 Sylvilagus transitionalis, New England Cottontail.

Roan Mountain

Roan Mountain lies in northeastern Mitchell County and adjacent Tennessee.

- E *Carex aenea*, Fernald's hay sedge. Round, Jane, and Grassy Balds.
 Carex misera, Wretched sedge.
 Geum geniculatum, Bent avens.
 Geum radiatum, Spreading avens. Round, Jane, and Grassy Balds; heath balds on Roan High Bluff; grass balds at summit of Roan High Knob and east of Carver's Gap.
 Sedum rosea, Roseroot.
 Solidago spithamea, Blue-ridge goldenrod. Round, Jane, and Grassy Balds; heath balds on Roan High Bluff.
 Trisetum spicatum var. *molle*, Soft trisetum. Round, Jane, and Grassy Balds.
 Myotis sodalis, Indiana Myotis. Summer forest records.
- T *Liatris helleri*, Heller's gayfeather. Round, Jane, and Grassy Balds.
 Lilium grayi, Gray's lily. Round, Jane, and Grassy Balds.
 Prenanthes roanensis, Roan rattlesnakeroot. Round, Jane, and Grassy Balds; grass balds at summit of Roan High Knob and east of Carver's Gap.
 Rhododendron vaseyi, Pink-shell azalea.
 Saxifraga careyana, Carey saxifrage.

Aegolius acadicus, Saw-whet owl. Breeds in spruce-fir forests.
Glaucomys sabrinus coloratus, Northern Flying Squirrel.
 Spruce-fir and adjacent hardwood stands.

- SC *Corvus corax*, Common raven.
 Dendroica virens, Black-throated green warbler.
 Regulus satrapa, Golden-crowned kinglet.
 Sitta canadensis, Red-breasted nuthatch.
 Both species breed in spruce-fir forests.
- U *Pterostichus manicus plethorus*, a carabid beetle.
 Buteo platypterus, Broad-winged hawk.
 Loxia curvirostra, Red crossbill. May nest in pine habitats.
 Mustela nivalis allegheniensis, Least Weasel.
 Myotis lucifugus lucifugus. Little Brown Myotis.
 Sylvilagus transitionalis, New England Cottontail.

Grandfather Mountain

Fifteen species of concern occur in an area at the junction of Avery, Caldwell, and Watauga counties, most of them on or very near Grandfather Mountain.

- E *Geum geniculatum*, Bent avens.
 Geum radiatum, Spreading avens.
 Sedum rosea, Roseroot.
 Solidago spithamea, Blue-ridge goldenrod.
- T *Cymophyllus fraseri*, Fraser's sedge.
 Liatris helleri, Heller's gayfeather.
 Rhododendron vaseyi, Pink-shell azalea.
 Certhia familiaris, Brown creeper. Nests in spruce-fir and adjacent hardwoods.
- SC *Corvus corax*, Common raven. Currently nesting on Grandfather Mountain.
 Regulus satrapa, Golden-crowned kinglet.
 Sitta canadensis, Red-breasted nuthatch.
 Plethodon welleri, Weller's Salamander. Elevations above 1,500 meters (about 5,000 feet).
 Ursus americanus, Black Bear.
- U *Pterostichus manicus plethorus*, a carabid beetle.
 Empidonax alnorum, Alder flycatcher. Bogs near Blowing Rock.

Black Mountains and Mount Mitchell

The area under consideration here lies in Yancey and Buncombe counties.

- E *Betula papyrifera* var. *cordifolia*, Mountain paper birch. High

Cluster Areas -- Blue Ridge

- altitude spruce-fir forest. Mount Mitchell; Celo Mountain.
Geum radiatum, Spreading avens. Rocky balds, Mount Craig.
- T *Cymophyllus fraseri*, Fraser's sedge. Mount Mitchell; north of Camp Alice.
Prenanthes roanensis, Roan rattlesnakeroot. Mount Mitchell.
Aegolius acadicus, Saw-whet owl.
Certhia familiaris, Brown creeper.
?Parus atricapillus, Black-capped chickadee. Apparently extirpated from the Black Mountains by destruction of spruce-fir habitat.
Glaucomys sabrinus coloratus, Northern Flying Squirrel. Mount Mitchell (extirpated?).
- SC *Microhexura montivaga*, North Carolina Funnelweb Tarantula.
Type locality is spruce-fir forest on Mount Mitchell; may be endemic.
Adelopsis mitchellensis, a leptodirid beetle. High altitude spruce-fir forest, Mount Mitchell.
Adelopsis n. sp., an undescribed leptodirid beetle. Mount Mitchell.
Trechus carolinae, a carabid beetle. Type locality is peak of Mount Mitchell; Celo Mountain.
Trechus mitchellensis, a carabid beetle. Type locality is Celo Mountain.
Corvus corax, Common raven.
Regulus satrapa, Golden-crowned kinglet.
Sitta canadensis, Red-breasted nuthatch.
Both species seem dependent on the high altitude spruce-fir habitat.
- U *Anguispira paucicostata*, Mount Mitchell Snail. Endemic, Mount Mitchell; may be extinct.
Agonum gracilentum, a carabid beetle.
Pterostichus carolinus carolinus, a carabid beetle.
Pterostichus manicus plethorus, a carabid beetle.
Pterostichus palmi, a carabid beetle.
These four species occur at high altitudes.
Microtus chrotorrhinus carolinensis, Rock Vole.
Parascalops breweri, Hairy-tailed Mole.
Sylvilagus transitionalis, New England Cottontail.

Great Craggy Mountains

This range lies southwest of the Black Mountains.

- E *Carex biltmoreana*, Biltmore sedge. Craggy Dome and Craggy Mountain.
Carex misera, Wretched sedge. Craggy Gardens; Craggy Pinnacle; summit of Craggy Mountain.
Geum radiatum, Spreading avens. Craggy Pinnacle.

Juncus trifidus var. *monanthes*, One-flowered rush. Craggy Gardens.

- T *Lilium grayi*, Gray's lily. Craggy Dome.
 Prenanthes roanensis, Roan rattlesnakeroot. Craggy Mountain.
- SC *Certhia familiaris*, Brown creeper.
 Regulus satrapa, Golden-crowned kinglet.
 Sitta canadensis, Red-breasted nuthatch.
 All three of these birds are species of high elevation spruce-fir forests.

Great Smoky Mountains National Park

This area covers a great deal of territory, extending from south-central Madison County southwest to the Swain-Graham counties line.

- E *Cacalia rugelia*, Rugel's ragwort. Spruce-fir. Mount Sterling; Andrews Bald.
 Carex misera, Wretched sedge. Clingman's Dome.
 Glyceria nubigena, Smoky-mountain mannagrass. Andrews Bald.
 Mesodon jonesianus, Newfound Gap Helix. Newfound Gap.
 Felis concolor, Mountain Lion or Panther. Sightings.
- T *Cladrastis lutea*, Yellowwood. Mount Sterling; Pigeon River Gorge (northeast of the Park).
 Cymophyllus fraseri, Fraser's sedge. Near Smokemont.
 Habenaria peramoena, Purple fringeless-orchid.
 Panax quinquefolium, Ginseng. Near Smokemont.
 Prenanthes roanensis, Roan rattlesnakeroot.
 Rhododendron vaseyi, Pink-shell azalea.
 Saxifraga careyana, Carey saxifrage. Clingman's Dome.
 Synandra hispidula, Synandra.
 Aegolius acadicus, Saw-whet owl.
 Certhia familiaris, Brown creeper.
 Nuttallornis borealis, Olive-sided flycatcher.
 Parus atricapillus, Black-capped chickadee.
 Glaucomys sabrinus coloratus, Northern Flying Squirrel.
 The above five species are limited to, or strongly dependent on, spruce-fir habitat. The Brown creeper and Northern Flying Squirrel also occur in adjacent hardwood forests.
- SC *Trechus luculentus*, a carabid beetle.
 Trechus novaculosus, a carabid beetle.
 Clingman's Dome is the type locality of both beetles.
 Trechus subtilis, a carabid beetle.
 Corvus corax, Common raven.
 Regulus satrapa, Golden-crowned kinglet.
 Sitta canadensis, Red-breasted nuthatch.
 Ursus americanus, Black Bear.
- U *Aglenus brunneus*, a colydiid beetle.

Cluster Areas -- Blue Ridge

Agonum gracilentum, a carabid beetle.
Nebria appalachia, a carabid beetle.
Pterostichus carolinus fumorum, a carabid beetle.
Pterostichus unicarum, a carabid beetle.
Pterostichus primus, a carabid beetle.
Pterostichus palmi, a carabid beetle.

Most of these beetles occur in spruce-fir habitats.
Loxia curvirostra, Red crossbill.
Microsorex hoyi winnemana, Pygmy Shrew.
Microtus chrotorrhinus carolinensis, Rock Vole. Fairly common in the Park; type locality is 9 km (5 mi.) north of Smokemont.
Myotis keenii septentrionalis, Keen's Myotis.
Myotis lucifugus lucifugus, Little Brown Myotis.
Parascalops breweri, Hairy-tailed Mole.
Plecotus rafinesquii macrotis, Rafinesque's Big-eared Bat.
Sciurus niger, Eastern Fox Squirrel.
Sorex dispar blitchi, Long-tailed Shrew.
Sylvilagus transitionalis, New England Cottontail.

Mount Pisgah and Vicinity

This locality is on the line between Haywood and Buncombe counties.

- T *Helonias bullata*, Swamp pink.
 Aquila chrysaetos, Golden eagle.
- SC *Agathidium n. sp.*, an undescribed leioid beetle. Known from only a few specimens collected on Mount Pisgah.
 Corvus corax, Common raven.
 Regulus satrapa, Golden-crowned kinglet.
 Sitta canadensis, Red-breasted nuthatch.

Shining Rock Wilderness Area

- E *Dalibarda repens*. Robin-run-away.
 Helonias bullata, Swamp pink.
 Both plants are known from bogs.
- T *Aquila chrysaetos*, Golden eagle. Observed in the area.
- SC *Corvus corax*, Common raven. Eighty-five were seen on Black Balsam Mountain in 1973.

Plott Balsam Mountains

This range extends southwest from Plott Balsam (Knob) in western Haywood County to the Tuckasegee River in western Jackson County.

- E *Pallaea X wrightiana*, Wright's cliff-brake fern. Granite

outcrops on Joe Mountain.

- T *Rhododendron vaseyi*, Pink-shell azalea.
 Aegolius acadicus, Saw-whet owl.
 Aquila chrysaetos, Golden eagle. Wintering. Seen at Jones
 Knob (Mt. Lynn Lowrey).
 Certhia familiaris, Brown creeper.
 Parus atricapillus, Black-capped chickadee.
- SC *Regulus satrapa*, Golden-crowned kinglet.
 Stygonectes sp. B, an undescribed amphipod. Seeps at 1,500
 meters (5,000 feet) below Jones Knob (Mt. Lynn Lowrey).
 Trechus balsamensis, a carabid beetle.
 Trechus rosenbergi, a carabid beetle.
 These beetles occur on Waterrock Knob, which is the type
 locality for both.
- U *Mesodon orestes*, Avenger Helix. Endemic snail, from 1,860
 meters (6,200 feet) on Waterrock Knob.
 Psilocnemis leucosticta, a scarab beetle. Rare commensal
 with ants, from near Balsam, Haywood County.

Gorges in Southern Transylvania County

Several river and creek gorges in Transylvania County contain plants of concern.

- E *Asplenium monanthes*, Single-sorus spleenwort fern. White-
 water River Gorge; Bearwallow Creek Gorge (Toxaway); once
 occurred in Thompson River Gorge but appears to be gone.
 Shortia galacifolia, Shortia or Oconee bells. Whitewater
 River Gorge; Thompson River Gorge; Horsepasture River
 Gorge; Bearwallow Creek Gorge (Toxaway); Bearcamp Gorge.
- T *Calamagrostis porteri*, Porter's reedgrass. Thompson River
 Gorge.
 Panax quinquefolium, Ginseng. Whitewater River Gorge;
 Horsepasture River Gorge; Bearwallow Creek Gorge (Toxaway).
 Rhododendron vaseyi, Pink-shell azalea. Thompson River Gorge.

Highlands and Vicinity

Seventeen species of concern occur within an approximate 8 km
(5 mi.) radius of Highlands, including much of the Highlands Plateau.

- E *Carex misera*, Wretched sedge. Satulah Mountain.
 Carex purpurifera, Purple sedge. Horse Cove.
 Grammitis nimbata, Dwarf polypody fern. Dry Falls.
 Senecio millefolium, Divided-leaf groundsel. Rock outcrops.
 Slick Rock, and an area from Bearden Mountain to Chatooga
 Cliffs.

Cluster Areas -- Blue Ridge

- T *Helonias bullata*, Swamp-pink. Mulkey Gap Bog (property of Highlands Biological Station).
Rhododendron vaseyi, Pink-shell azalea. Whiteside Mountain.
Saxifraga careyana, Carey saxifrage. High Falls.
Certhia familiaris, Brown creeper. White pine, Plateau.
- SC *Aneides aeneus*, Green Salamander. Rock crevices. Several sites near Highlands, including Biological Station property.
Eumeces anthracinus, Coal Skink. Moist, humid areas in hardwood forests; several localities.
Regulus satrapa, Golden-crowned kinglet. White pine, Plateau.
Sitta canadensis, Red-breasted nuthatch. White pine, Plateau.
- U *Maronetus unistriatus*, a carabid beetle. Forest litter, Plateau.
Loxia curvirostra, Red crossbill. Nests in pine woods.
Myotis lucifugus lucifugus, Little Brown Myotis.
Parascalops breweri, Hairy-tailed Mole.
Synaptomys cooperi stonei, Southern Bog Lemming.

Nantahala Mountains and Vicinity

This area extends from the southern boundary of Great Smoky Mountains National Park, south through Macon County to the Blue Ridge Mountains.

- E *Buckleya distichophylla*, Piratebush. Parasitic on hemlock. Camp Branch Falls, Nantahala Gorge.
Carex purpurifera, Purple sedge. Vicinity of Rainbow Springs.
Glyceria nubigena, Smoky-mountain mannagrass. Vicinity of Coweeta Hydrologic Laboratory.
Poa languida, Torrey bluegrass.
Sporobolus heterolepis, Prairie dropseed.
Both of these plants occur on the Buck Creek serpentine-olivine barrens.
Felis concolor, Mountain Lion or Panther. Sightings reported.
- T *Calamagrostis porteri*, Porter's reedgrass. Buck Creek serpentine-olivine barrens.
Cladrestis lutea, Yellowwood. Vicinity of Standing Indian Mountain.
Cymophyllus fraseri, Fraser's sedge. Blowing Springs marble bluffs; vicinity of Rainbow Springs; vicinity of Standing Indian Mountain.
Habenaria flava, Southern rein-orchid. Near Little Tennessee River northeast of Round Top Mountain; Wayah Bald.
Habenaria peramoena, Purple fringeless-orchid. Vicinity of Rainbow Springs.
Panax quinquefolium, Ginseng. Nantahala Gorge; vicinity of Rainbow Springs.
Rhododendron bakeri, Cumberland azalea. Wayah Bald.
Saxifraga careyana, Carey saxifrage. Nantahala Gorge; along Little Tennessee River at US 19.

Clemmys mühlenbergi, Bog Turtle. Montane bog-meadow habitats. Aquone; Rainbow Springs; vicinity of Standing Indian Mountain.

Certhia familiaris, Brown creeper.

- SC *Arianops* (a number of species), pselaphid beetles. Vicinity of Coweeta Hydrologic Laboratory (see Cornell's account in *Freshwater and Terrestrial Arthropods*).
- Ambystoma talpoideum*, Mole Salamander. One locality along Little Tennessee River.
- Eurycea longicauda longicauda*, Long-tailed Salamander. Flood-plains, upper Nantahala.
- Eumeces anthracinus*, Coal Skink.
- Corvus corax*, Common raven.
- Regulus satrapa*, Golden-crowned kinglet.
- Sitta canadensis*, Red-breasted nuthatch.
- U *Maronetus unistriatus*, a carabid beetle.
- Hemidactylium scutatum*, Four-toed Salamander.
- Sorex palustris punctulatus*, Water Shrew. Upper reaches of Fires Creek, Clay County (only known site in state).

New River System

- T *Cambarus (Hiaticambarus) chasmodactylus*, New River Riffle Crayfish. Endemic to this system in North Carolina.
- Stenelmis gammoni*, an aquatic elmid beetle. Endemic, South Fork.
- Etheostoma kanawhae*, Kanawha darter.
- Phenacobius teretulus*, Kanawha minnow.
- Both of these fishes endemic in this system in the state.
- SC *Exoglossum laurae*, Tonguetied minnow.
- Nocomis platyrhynchus*, Bigmouth chub.
- Both of these fishes endemic in this system in the state.
- Notropis rubellus*, Rosyface shiner.
- Notropis scabriceps*, New River shiner.
- Percina maculata*, Blackside darter.
- Percina oxyrhyncha*, Sharpnose darter.
- Pimephales notatus*, Bluenose minnow.
- These four species are endemic in this system in the state.
- Cryptobranchus alleganiensis alleganiensis*, Hellbender.
- U *Spirodon dilatatum*, Kanawha Riversnail. Endemic in this system in North Carolina.

French Broad River System

- Ex *Etheostoma acuticeps*, Sharphead darter. Toe River.
- Hybopsis monacha*, Spotfin chub. Old records for Swannanoa River, and Spring Creek at Hot Springs.

Cluster Areas -- Blue Ridge

- Ex? *Esox masquinongy*, Muskellunge. Native populations may be extirpated.
Etheostoma maculatum, Spotted darter. Northwestern Madison County.
Etheostoma simoterum, Tennessee snub-nosed darter. Old records, probably from northwestern Madison County.
Noturus eleutherus, Mountain madtom. Near Hot Springs.
- E *Percina burtoni*, Blotchside logperch. South Toe; old record for Swannanoa. May be extirpated.
Percina macrocephala, Longhead darter. Near Skyland, southern Buncombe County. May be extirpated.
Etheostoma jessiae, Blueside darter. Mills River, northeastern Henderson County.
Hiodon tergisus, Mooneye. Near Hot Springs.
? *Polyodon spathula*, Paddlefish. Based on old statement that it ascended the French Broad to Asheville; no voucher specimens.
- T *Percina caprodes*, Logperch. Northwestern Madison County.
- SC *Cambarus (Puncticambarus) reburus*, French Broad Stream Crayfish. North Carolina endemic. Headwaters and tributaries of French Broad River in Buncombe, Henderson, and Transylvania counties. Also in Savannah headwaters.
Carpionodes carpio, River carpsucker. Northwestern Madison County.
Micropterus punctulatus, Spotted bass. Northwestern Madison County.
Percina aurantiaca, Tangerine darter. Northwestern Madison County; Swannanoa River.
Percina sciera, Dusky darter. Northwestern Madison County.
Percina squamata, Olive darter. Northwestern Madison County; Toe River (where it is considered Threatened).
Cryptobranchus alleganiensis alleganiensis, Hellbender. A number of large streams in the system.

Little Tennessee River System

- Ex? *Esox masquinongy*, Muskellunge. Native populations may be extirpated.
- SC *Etheostoma maculatum*, Spotted darter. Cullasaja and Oconoluftee rivers.
Hybopsis monacha, Spotfin chub. Between Franklin and Fontana Reservoir.
Percina aurantiaca, Tangerine darter. Tuckasegee and Santeetlah rivers.
Cryptobranchus alleganiensis alleganiensis, Hellbender. Larger streams in the system.

Savannah River Headwaters

- SC *Cambarus (Puncticambarus) reburus*. French Broad Stream Crayfish. Type locality is a small tributary to Horsepasture River east of Cashiers, Jackson County.
 Etheostoma inscriptum, Turquoise darter.
 Hybopsis rubrifrons, Rosyface chub.
 Micropterus coosae, Redeye bass.
 These three fishes occur in eastern streams of the system.
 Nocomis leptocephalus interocularis, Bluehead chub. Throughout the headwaters.

Hiwassee River System

- SC *Carpionodes carpio*, River carpsucker. Extreme northwestern portion of the system.
 Micropterus punctulatus, Spotted bass. Nottely River.
 Percina squamata, Olive darter. Two localities in central Cherokee County.
 Cryptobranchius alleganiensis alleganiensis, Hellbender.
 Probably in larger streams throughout the system.

Discussion

Bob Teulings: I am a little surprised that there hasn't been more mention of the Dismal Swamp area today. It was conspicuously vacant on the botanical map that we saw earlier, but it has been mentioned in several other contexts. State and federal land acquisition efforts at the Dismal Swamp in North Carolina have been very active recently and there is well over 15,000 acres now in public ownership. These areas need to be thoroughly inventoried at this point. We have very little specific resource data.

Dave Lee: I just wanted to say that we had four subspecies of mammals that are endemic to the Dismal Swamp.

Ed Menhinick: Could you bring us up to date on the New River dam?

Teulings: Well, that effort is going on on two fronts now. First of all the case is in court, and the state feels it's in a very strong position to stop the dam project by a court ruling. The other avenue of approach is to have national Scenic River designation for the site, or for a portion of the New River in North Carolina. That is under study now by the Department of Interior. They're circulating their environmental impact statement on the implications of that action. We expect favorable action there.

Jim Farnell: I'm not sure what John Funderburg is going to say about the next step, but it would seem to me to be most appropriate as a next step

Cluster Areas -- Discussion

to this conference to shift direction slightly and meet again sometime in the relatively near future to talk about places. And, instead of us bird people separating ourselves off and the plant people separating themselves off, if we could put together teams to talk about particular localities we could begin to build our case for habitats in a much better fashion than we will be able to do at this point.

Teulings: I would concur with that completely.

Ben Sanders: Bob, I might also mention in respect to Cluster Areas, the pocosin area and the Carolina bays, as well as the mountain balds and bogs, as extremely important communities that perhaps need attention.

Teulings: Thank you for mentioning all of those. Again, I concur with you completely. I was going to mention on my own, and overlooked it here, the Green Swamp area in southeastern North Carolina as very important from several of those aspects.

Frank Schwartz: As a matter of information, in relation to your comment on the Dismal Swamp, there is a paper now in press which will be in the Virginia Academy of Sciences on the fishes of that area, plus comparisons to adjacent areas to the south and north.

Tom Quay: Sam Moore, you said something earlier today about money involved in this kind of stuff.

Sam Moore: I talked to Dr. Quay, I just asked that it seemed that something was missing and this is the economics of this. We can consider them competitors. These are dear to our hearts, but the money will be dear to the hearts of those that control this, and nothing has been said about this and what effect this would have on the economy.

Quay: Maybe that's what's going to be in Jim Parnell's next thing, areas and money both. Do you have anything more to say, Frank Barick? You're involved in this area business an awful lot.

Frank Barick: Well, really I don't have much to say about the areas other than we are actively working toward preservation or working against some of the adverse impacts, whether they be channelization, or dredging, or what have you. We're very much concerned about this activity, and we spend a lot of time looking into these things and trying to point out the values that are being affected. And, of course, we're also very much concerned about the future of this whole program, since the Wildlife Resources Commission has been pretty much recognized as going to be the lead agency insofar as regulation, control, and implementation of any protective laws and regulations that pertain to these various species, both plants and animals. So, we are also very grateful for all of the input that has developed here today, and we are looking forward to examining very carefully the printed results of this Symposium. As the Wildlife Commission's program develops we will be looking to you people that are here as specialists to advise the Commission in regard to these various species that will require particular attention. So, once again we appreciate very much all of the very meaningful input that has

developed here today.

Marc Imlay: One Cluster Area that I think we have overlooked is the Tar River. We had, I think, four clams in there, altogether, and there was a fish in the Neuse and Tar, *Noturus furiosus* I believe. Isn't there a salamander? I think it comes out to six or seven species.

Epilogue

A lot of talent and expertise has been brought to bear on the biological problems discussed in this book. Fairly widespread lines of communication have been established in pulling together the committees on various groups of organisms, and we anticipate that this will be an ongoing effort.

Three major themes emerged from the 1975 Symposium. The first was an emphasis on protecting ecosystems as a primary strategy for protecting endangered and threatened species. Here a team approach is needed, since our ignorance of the composition, structure, and functioning of these total systems is great. The second emergent theme was the overriding need for more research on the species of concern, and others with which they are involved. The preponderance of forms in the *Undetermined* category speaks loudly to this need for research into such biological basics as taxonomy, distribution, general ecology, and, in short, the overall natural history of North Carolina's plants and animals. The Symposium planners gathered the most expert opinion we could find, but the experts often had to say, "Our findings are preliminary, we need to know more."

The third major theme was the need for educating non-biologists to the scope and magnitude of these problems, and the values of endangered, indeed all, species. We agree with Victor Scheffer (1974. *A Voice for Wildlife*, p. 193) that a knowledge of the laws of nature is at least as important to every child as knowing the rules of Little League baseball. In our educational endeavors we need to emphasize the balance of life, and to make sure that these principles are given every consideration in public decisions affecting the integrity of our environment.

In summary, despite its infallibility we cannot settle for *ex post facto* wisdom in dealing with these matters. The 1975 Symposium and this volume are, we hope, first steps in developing programs to protect our dwindling biota. These efforts must not be allowed to become empty academic exercises.

The Editors

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Cornell, J. F., Jr. 1977. *Stenelmis gammoni* White and Brown. pp. 208-209, *In*: (cite the *Volume*, as indicated above).

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Schwartz, F. J. 1977. *Chelonia mydas mydas* (Linnaeus). Atlantic Green Turtle. pp. 304-305, *In*: (cite the *Volume*, as indicated above).

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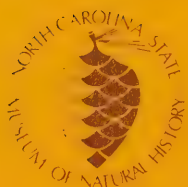
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The adult Brown Pelicans on the cover were photographed at Ocracoke, North Carolina in July, 1959, by Jack Dermid. Photo courtesy of the North Carolina Wildlife Resources Commission.



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